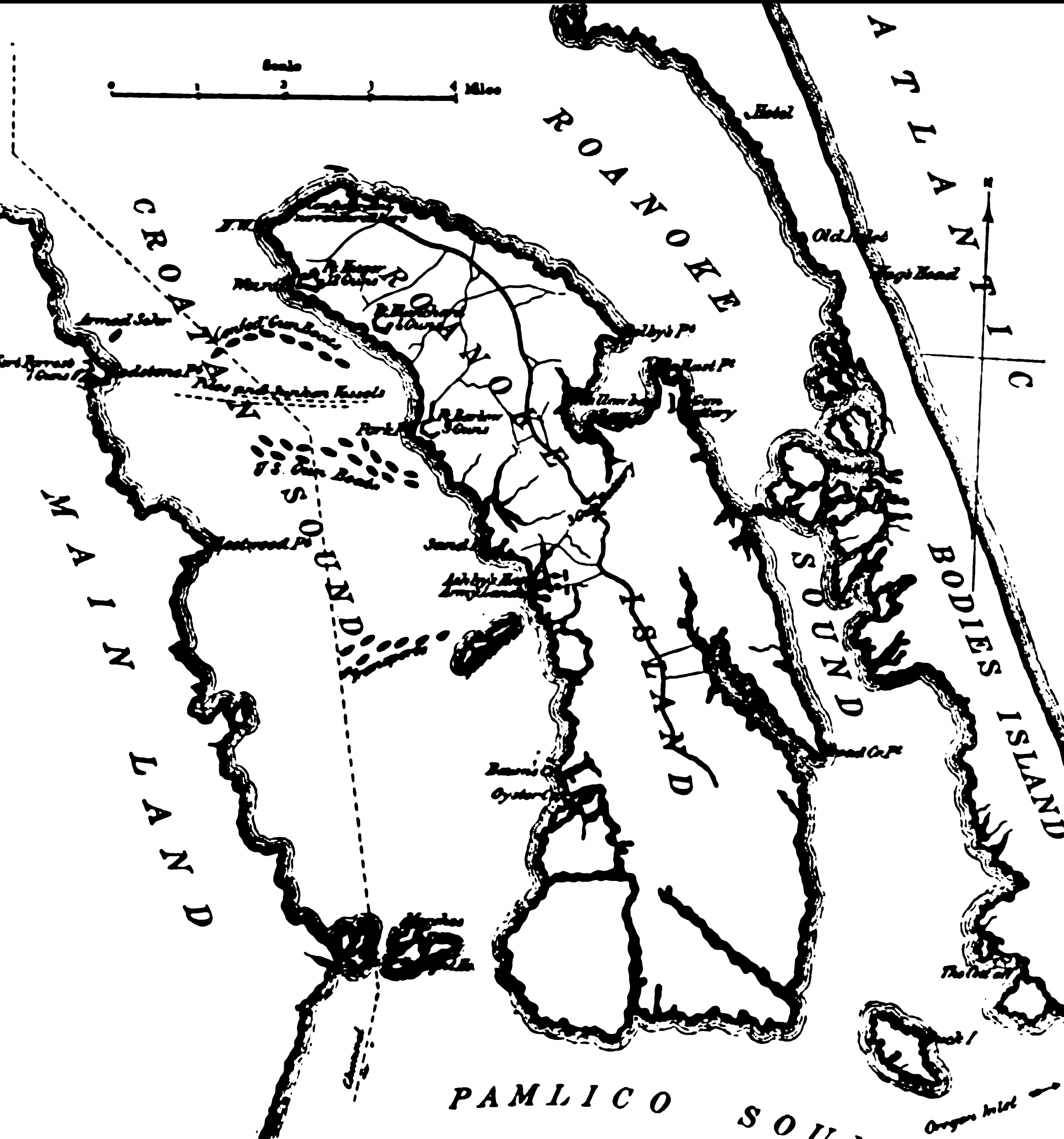


# Journal of the United States Artillery

United States Coast Artillery Training Center, Fort Monroe, Va

the bombardment that powder measures were improvised from vegetable tins, that columbiad shells were strapped with strips of old tents, and that fuse plugs were whittled out by hand during the night.

There were several boats belonging to the Navy but they took no part in the actual bombardment, and the Confederate gunboats after the first few days were not in evidence.

### Narrative of Events

In accordance with the plan of Captain Gillmore, the 46th New York Volunteer Infantry was sent in the early part of December, 1861, to occupy Big Tybee Island, and operations incident to investing Fort Pulaski were begun. About the middle of January, 1862, a joint expedition was organized by General Sherman and Commodore Du Pont, consisting of one regiment of infantry (48th N. Y. Vols.), two companies of New York Volunteer Engineers, two companies of the 3rd Rhode Island Heavy Artillery, with twenty guns of various calibers and accompanied by three gunboats.

These troops were to rendezvous at Daufuskie Island, where, earlier in January, three companies of the 7th Connecticut Volunteers had landed. This island was the nearest land available and suitable for a base, it being the only dry land in the vicinity, and was some four miles from Fort Pulaski. Another mixed force was sent about the same time to the south of the Savannah River to Wilmington Narrows, it being intended to cut off Fort Pulaski from all outside communication.

By the 12th of February a battery (Battery Vulcan) consisting of one 8-inch howitzer, three 30-pounder Parrotts, and two 20-pounder Parrotts, was erected on Jones Island at Venus Point; and by February 20th one on Bird Island (Battery Hamilton) consisting of one 8-inch howitzer, one 30-pounder Parrott, one 20-pounder Parrott, and three 12-pounder James rifles. These works were about four miles above the fort and on the river.

In addition, two companies of infantry with three pieces of artillery were placed on a hulk anchored in Lazaretto Creek two and a quarter miles south of the fort, to intercept communication from the direction of Wassaw Sound. But with all these preparations it was not possible to isolate Fort Pulaski absolutely—messengers frequently passed to and from the fort. Some of them, however, were captured.

On the morning of the 13th of February the Venus Point battery (Battery Vulcan) came into action, firing upon the Confederate steamer *Ida* as she came down the river. Nine shots were fired at her but she was unhurt, all shots passing astern. Captain Gillmore states in his report that not enough correction was made for the travel of the vessel. In this fire all the guns except one recoiled off their platforms. The platforms were at once enlarged to double size. The *Ida* returned to Savannah by another route. On the next day, the Confederate gunboats engaged the battery for a short time; but after one was struck, they withdrew.

On February 19th active work was begun on Big Tybee Island. The first vessel with ordnance and ordnance stores arrived from the North in Tybee Roads on February 21st. The blockade of Fort Pulaski may be said to have been effective from February 22nd on.

From February 21st to April 9th all troops on Tybee Island were engaged in building batteries, and making preparations necessary to engage the guns of Fort Pulaski.

On the afternoon of April 9th everything was in readiness to open fire. General orders were issued prescribing for each battery its point of attack, rate of fire, length of fuse, charge, and elevation.*

The mortars were to drop their projectiles within the work, while the fire of the guns was to be directed mainly against the barbette guns of the fort, and was to take the gorge and north walls in reverse. The *pan-coupé* joining the south and southeast faces was an especial target for the guns, the plan being to open a practicable breach for assault and to expose to a reverse fire the magazine in the opposite angle.

Just after sunrise on the 10th of April, Major General Hunter, Commanding the Department of the South, sent a flag by one of his aides to the fort demanding its surrender. Colonel Olmstead briefly declined to comply with the demand, stating that he was there "to defend the fort, not to surrender it."

Firing then opened up, the first shell, at 8:15 a.m., coming from Battery Halleck, situated in about the center of the line. By half past nine all batteries were in action, each mortar firing at 15-minute intervals and the guns two to three times as fast.

* See *Official Records of the Union and Confederate Armies*, Series I, vol. vi, pages 156, 157.

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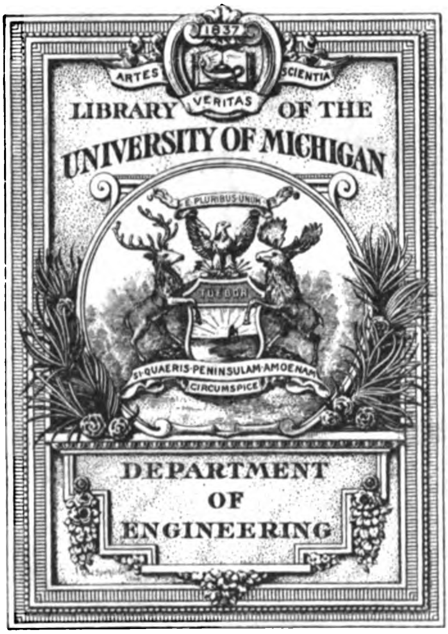
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# JOURNAL OF THE UNITED STATES ARTILLERY

PUBLISHED UNDER SUPERVISION OF THE SCHOOL BOARD
OF THE COAST ARTILLERY SCHOOL

VOLUME 40
1913

FORT MONROE, VIRGINIA
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1913

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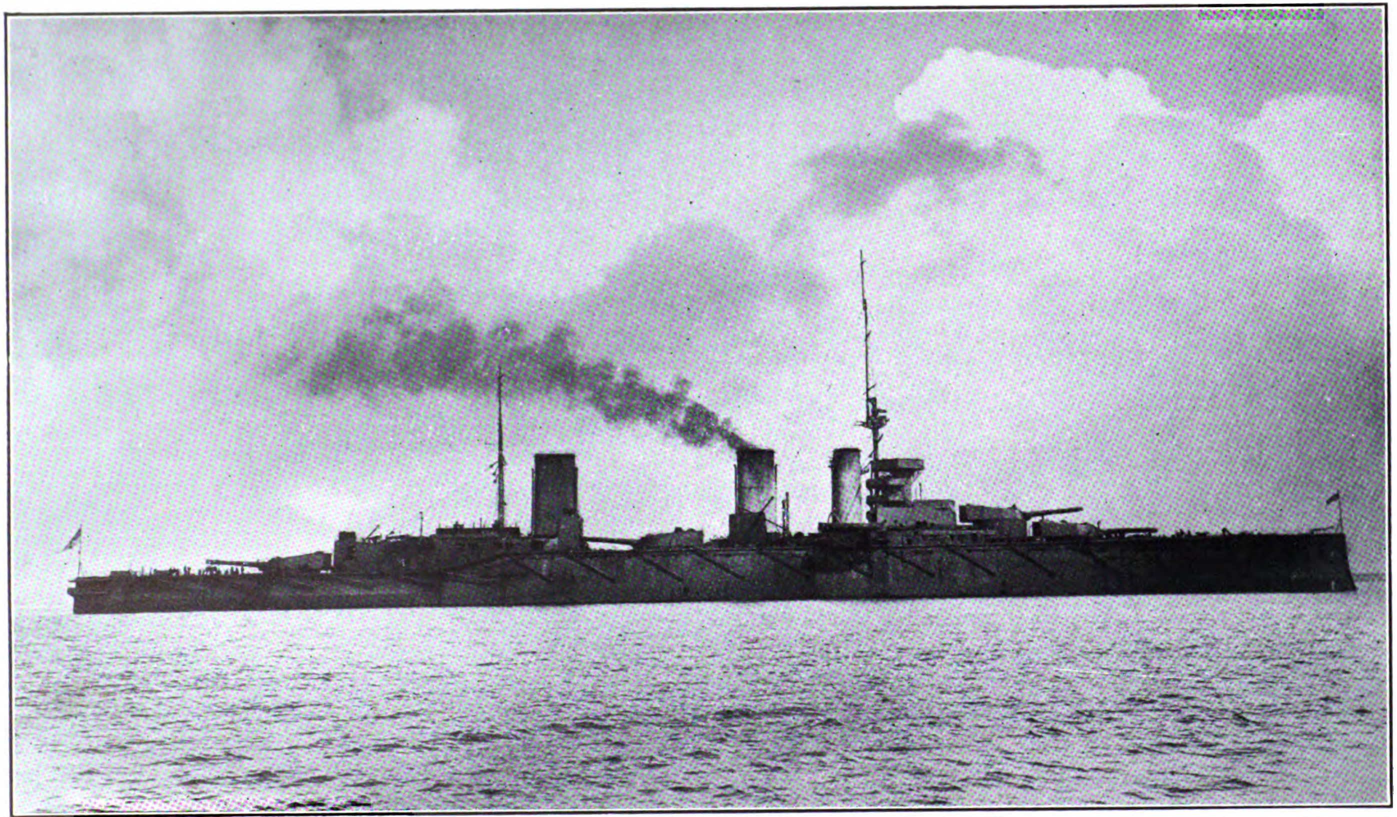


Photograph by Stephen Cribb, Southsea. 1283

H. M. Battle-Cruiser Queen Mary

(See page 123.)

# JOURNAL

OF THE

# UNITED STATES ARTILLERY

*"La guerre est un métier pour les ignorans
et une Science pour les habiles gens."*

VOL. 40 No. 1 JULY—AUGUST, 1913 WHOLE No. 122

## Second Prize, Essay Competition of 1912

# WHAT IS THE BEST TYPE OF PROJECTILE FOR THE EXISTING ARMAMENT OF THE SEACOAST FORTIFICATIONS OF THE UNITED STATES?

BY CAPTAIN LUCIAN B. MOODY, ORDNANCE DEPARTMENT

Considering the varied type of the armament at present installed in our seacoast fortifications and the fact that no one kind of projectile is suitable for all of the three main elements of the gun defense—mortars, rapid fire guns, and heavy guns—the first question that naturally arises is, which of the above elements is the most deficient at the present time in any important factor such as range, danger space, or penetration.

The above question can be answered either by considering the elements one by one in a process of elimination, or by assuming that there will be little discussion or difference of opinion regarding those which are fairly satisfactory and considerable discussion, in a wide awake service, regarding any that are generally regarded as unsatisfactory.

The type of mortar used in eighty per cent of the emplacements in the United States was adopted twenty-two years ago,

but is at the present day capable of penetrating at a range of 15,000 yards the deck armor of any ship with a projectile weighing 700 pounds and carrying a high explosive charge of 24 pounds. It has recently been considered expedient to adopt for new manufacture a mortar with a maximum range of 20,000 yards, but the old mortar can surely still be counted as a weapon measuring well up to present requirements.

At the time of the Spanish War there were practically no rapid fire guns mounted on our coasts, and hence with few exceptions the guns at present mounted are of comparatively recent design and manufacture. It is to be regretted that, due to erosion, the power obtained from many of them is less than they were designed to give; but the recent decision to apply pointed caps, or wind shields, to flatten the trajectory and increase the range and penetration will do much toward offsetting the loss caused by the reduction in velocity for the purpose of reducing erosion. Furthermore, the application of broad bands to the projectiles has so increased the accuracy life of the guns that in case it becomes absolutely necessary to have more muzzle energy, at least part of the reserve power can be utilized by a moderate increase in velocity.

In the primary gun armament we find 8-inch, 10-inch, and 12-inch rifles. With few exceptions the important points in the design of all of these were adopted in 1888, and the characteristics of the different calibers are essentially the same. Consideration of one caliber is, therefore, sufficient for the purposes of this article, and the 12-inch is chosen, as it is the gun intended to cope with capital ships carrying the heaviest guns and armor afloat. Seventy per cent of these guns are mounted on carriages which limit to ten degrees the angle of elevation at which they can be fired. The muzzle velocity was originally 2025 feet per second with a projectile weighing 1000 pounds. The heavy construction of the guns permitted the velocity to be increased to 2300 feet per second with the introduction of smokeless powder, but this was reduced to 2250 when, by capping, the projectiles were increased in weight to 1046 pounds. This weight is now, by the addition of a wind shield, being increased to 1700 pounds without any additional reduction in velocity. The resulting advantages of this particular feature are discussed in detail later; but, for the present, it is sufficient to say that with the modified projectiles the maximum range at which twelve-inch armor can be penetrated is 9500 yards with normal impact and 8450 yards with impact

thirty-five degrees from the normal, and that the maximum range permitted by the carriage is 13,300 yards. The accuracy life has been increased as in the case of the rapid fire guns by the adoption of broad banding for the projectiles; but it is unreasonable to expect any material increase in muzzle energy, for the simple reason that the pressures in the chamber and along the bore are at present about as high as it is probably advisable to use, although there is a liberal factor of safety. This point is emphasized because it can not be stated with certainty that some method of eliminating erosion will not be developed which will permit using at their full load guns now having a reserve of power. Creditable as the results of the efforts to increase the effectiveness of this weapon are, it is nevertheless apparent that a ship carrying modern naval guns and the present large allowance of ammunition can engage at a range at which the shore gun can not reply; or, if the object to be gained is worth while, can approach to what is now a comparatively short range with the risk of only nominal damage. The fact that this weapon has been supplanted in new manufacture by a gun of larger caliber and much greater power is a further proof that it is falling behind present requirements.

Considering current discussion, the writer can recall no really serious complaints regarding the power of either the rapid fire or mortar armament; although there have been and still are wide differences of opinion regarding the proper form of mounting, the muzzle velocities to be used, and similar questions. These should all be properly answered to secure the most efficient armament, but they can hardly be considered as vital. With regard to the 12-inch gun the case is different, as the claim of this piece to be counted much longer as a weapon to be feared by modern ships has been seriously questioned, and discussion has particularly centered on the question of whether to use shot or shell to secure the most effective results and the proper kind of fuze to use with each.

From the preceding analysis of present conditions, the writer believes it safe to assume that, in discussing the question of improvements in projectiles for the seacoast service, only the primary gun armament need be considered; and, as the question concerns only the general type of the projectile, it is thought that a statement showing in logical order the conditions covering the selection of a projectile for a single caliber of gun

will be more satisfactory than an attempt to deal with the several calibers collectively, which renders it difficult to introduce comparative numerical data without the use of tables. As before, the 12-inch gun is selected on account of its greater importance; and it is thought that a similar analysis of either the 8-inch or 10-inch caliber would lead to the same conclusions.

Having selected the caliber of gun to be studied, there are two methods which may be followed. We may assume that there is no ammunition now on hand and that provisions must be made for an entire new supply; or that the projectiles now on hand cannot be rejected and that the type to be adopted is to supplement the present supply. The first assumption would lead to a purely theoretical solution. Under the second, regard would be had for the existing supply of projectiles, of which about one third are armor piercing shot and two thirds armor piercing shell; and while many of them are not of as high quality as could be procured at the present time, the proportion of shot to shell seems to be about that now demanded by the artillery and all of them must be considered as serviceable until there is some rather revolutionary improvement in either armor or projectiles. It is, therefore, apparent that any projectiles which may be procured in the near future must be supplementary to the present supply, and may either be one of the present types or a third type which will have highly developed the desirable characteristics which are lacking at present.

The models now in use have recently been most carefully considered with a full appreciation that they were deficient in both range and penetrating power, and it may therefore be assumed that the improvements which have been decided upon are the best that can be incorporated in the light of present knowledge. That these improvements do much to bring the 12-inch gun up to present requirements must be admitted when it is remembered that the weight has been slightly increased, that the extreme range has been extended from 11,600 yards to about 13,300 yards, and that the penetration of twelve-inch armor has been extended from a possible 6300 yards to a possible 9500 yards, an increase in penetrating range of almost precisely fifty per cent.

It is, however, apparent that the maximum range is still far short of what is desirable, as evinced by the fact that the 14-inch gun, models of 1909 and 1910, has a range of over

18,000 yards and the 12-inch mortar, model of 1912, a range of 20,000 yards. It is sometimes argued that the dispersion of shots is so great that it will be unprofitable to expend ammunition at over, say, 11,000 yards, and there is considerable truth in this at the present time. Nevertheless, it would be rash to say that there is any range beyond which it should not be attempted to make hits; and it is conclusively demonstrated in the partial report of the "Board to make a study of the accuracy of seacoast guns," published as an appendix to the report of the Chief of Ordnance for 1910, that a powder which would produce the same muzzle velocity at every round would practically double the expected percentage of hits at all fighting ranges. Just how nearly we shall be able to produce the ideal powder referred to above can not be predicted; but that, at least, some improvement is to be expected is evident from the number of factors which are admittedly or possibly susceptible to improvement or of which the effect is as yet not fully understood. These include uniformity of dimensions of grain, the actual dimensions of the present form of grain, the form of grain, uniform arrangement of the grains in the chamber of the gun, the weight and arrangement of the igniter, variations in the percentages of moisture and volatiles, and the absorption of moisture under various conditions of exposure. That the effect of some of these factors is not thoroughly understood, and that there are possibly others inherent in the powder of which nothing is known, is indicated by the remarkable uniformity of some lots while other lots which as far as can be foreseen should give equal uniformity fail to do so. Whatever improvements may be developed will gradually be incorporated in the reserve powder supply, as approximately twelve per cent of this powder is expended in target practice each year.

It has now been shown that no increase in muzzle energy can be expected with the gun under consideration, that the maximum range with the present form of projectiles has probably been reached, that it will be necessary or at least desirable to fire at ranges greater than this maximum, and that there is some hope of an increased percentage of hits due to improvements in the uniformity of the powder. It is, therefore, thought that both of our present types of projectiles are vitally deficient for future requirements in their comparatively short maximum range, and that this can only be corrected by the adoption of a new form of projectile the design of which shall

be governed by the requirements that this range must be materially increased. As the muzzle energy must not be increased, it is at once evident that the price we must pay for our increased range is a decrease in the weight of the projectile; and it is believed that this conclusion is not radical in view of the fact that the weight of the mortar projectile has been twice reduced to secure increased range.

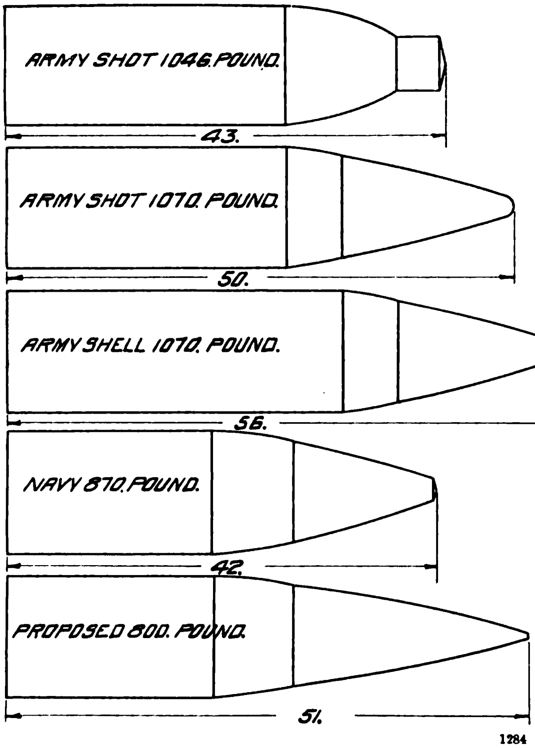
Having decided to adopt a type of lighter weight and increased range, the interior and exterior ballistic problems must first be solved in a manner that will give satisfactory results from a practical standpoint. Interchangeability of powder charges with the old type would, of course, be desirable; but, assuming that this can be accomplished theoretically, it would take a considerable number of years to put the scheme in practical operation, as a uniform granulation of powder grain would have to be used, and there are material differences between the granulation of the lots now in the reserve supply. It must, therefore, be accepted that, for the present at least, special charges would have to be provided for the new projectiles. This adds complication, but can not be consistently objected to, when there is necessity therefor, as long as we believe that we have successfully solved the control of mortar fire by a method involving the use of many different weights of powder charges and at least two different weights of projectiles. There is no difficulty in securing a granulation of powder which, with practically the same weight of charge, will duplicate the present pressure curve and at the same time produce an equal muzzle energy with the light projectile. Under these conditions it is hard to believe that there could be any objection to the proposed scheme on the ground of increased erosion, even though a higher muzzle velocity is to be used.

The weight and initial velocity, which are dependent upon each other, and the form of head must be determined to solve the exterior ballistic problem. For any assumed form of head and elevation of gun, the maximum range will be found to increase as the weight of the projectile is decreased. As this projectile is primarily intended for use at ranges where penetration of heavy armor will be unlikely, it will probably be desired to carry a fairly heavy bursting charge, which means a moderately heavy projectile, unless the armor piercing qualities and effective fragmentation are entirely sacrificed; and an exceptionally light projectile would probably be considered as a freak and not favorably accepted by the service even though

it might be theoretically advantageous. It is thought that the minimum weight to be adopted is 800 pounds, which is but slightly lighter than the standard projectiles used by several navies and is 100 pounds heavier than the lightest mortar projectile used in our service. It might be suggested that it would be well to make the gun projectile interchangeable with the 700 pound mortar projectile; but a little calculation will show that the gain in range with the high gun velocities is hardly great enough to justify a reduction in weight to this low limit. The selection of 800 pounds fixes the muzzle velocity at 2600 feet per second and the form of head fixes the extreme range.

Up to the present time the surfaces of the ogives of our sea-coast projectiles have been surfaces of revolution with an arc of a circle for the generating curve; and the steadiness in flight of such projectiles has been thoroughly tested with a radius of arc as great as seven times the diameter of the projectile. The coefficient of form of such a projectile is .54, assuming that a head struck with a two-caliber radius has a coefficient of form of unity. Hamilton's *Ballistics* (page 39, Part II) indicates that there is comparatively little gain beyond seven calibers, and a projectile having a head much longer would be difficult to design as well as too long to handle conveniently. Therefore .54 is selected as the best coefficient of form that can probably be secured in practice; and there would probably be some difficulty in securing as favorable a coefficient as this, if the seven-caliber form of head is selected, as it has been found impracticable to use such a large radius in actually modifying the old projectiles, an effective radius of slightly less than five calibers being the best that could be obtained. (The wind shield has a radius of seven calibers, but as the center is well in rear of the bourrelet some of the ballistic advantage is lost.) It is, therefore, desirable to find, if possible, a form of head which will have a coefficient of form as low as the seven-caliber head and yet be easier of practical application. A head of practically the same length along the axis of the projectile, designed in accordance with the formulæ of the Russian Professor Augustus, has a coefficient of .54 and has a surface lying, in general, nearer to the axis, which means a considerably lighter wind shield. This form can therefore be used without great difficulty, and there is thought to be no question but that it would be stable in flight, as it has been very thoroughly tested with small arms bullets. The exterior outline of the

proposed form is shown in the figure in comparison with the modified and unmodified army projectiles and the standard navy projectile. An 800 pound projectile with a coefficient of form of .54 fired with a velocity of 2600 feet per second should, at the maximum elevation of ten degrees, give a range of just over 16,000 yards, which is believed to be a sufficiently substantial increase in extreme range to warrant the adoption of the new type.




The remaining points to be decided upon are the kind and the weight of explosive charge, the armor piercing qualities, and the type of fuze. It is thought that the opinion of the majority of artillery officers would be in favor of making the new projectile a shell; but the question can be decided conclusively by determining whether the projectile will have a greater remaining energy than the present ones at 9500 yards, which is the limiting range for penetration of twelve-inch armor with the modified A. P. shot. As the remaining velocity at this

range is but slightly greater than that of the 1070 pound projectile, it is evident that we can expect it to do nothing in this line that can not be accomplished by the present armor piercing shot, and to give it the characteristics of a shot is simply to waste a large proportion of its explosive carrying ability. The projectile will, however, have sufficient energy at all ranges to penetrate light armor such as is carried by many ships as a protection for their rapid fire guns, and it would therefore probably be a mistake to make it a torpedo shell, even though this solution were not open to the objection that the shell would be inconveniently long. A little preliminary study indicates that there can be designed an 800 pound shell which will have as good armor piercing qualities as the present armor piercing shell, which will not greatly exceed the modified shot in length, and which will carry forty pounds of explosive "D". It is thought that this is about as good a compromise as can be found, although a more rigorous solution of the problem might indicate minor changes in all of the characteristics that have been assumed. Forty pounds of explosive is not as much as is carried by the present shell, but it is twice as much as is carried by the present shot and well over one and one half times as much as is carried by the navy shell or by our 700 pound mortar shell. The effect of this amount of explosive and the heavy fragments of the shell should be ample for about all the destruction that can be hoped for with the present gun at extreme ranges; and the shell is sufficiently strong to penetrate light armor at all ranges and armor of considerable thickness if used at the ranges at which the 1070 pound projectiles will normally be used. Explosive "D" has been assumed as the shell filler as it is the present standard and nothing has been suggested that promises to give materially better results.

The type of fuze is worthy of more study than any of the other features, as without a suitable fuze much of the effect of any explosive projectile is lost. This matter has been so thoroughly discussed by recognized authorities of both the Coast Artillery Corps and the Ordnance Department in connection with the question of a proper fuzing of our present shot and shell, that a brief reference only to the theoretical defects of the present fuzes is necessary. Assuming that penetration can be secured, there can be no question but that an interior explosion is more effective than an exterior one; and, therefore, a delay action fuze is used in the shot with a highly satisfactory

result in the case of striking and penetrating armor, but in the case of a glancing blow on armor or of striking some object which offers little resistance, such as a mast, the explosion may be so delayed as to be totally ineffective. On the other hand the present shell has been provided with a non delay action fuze which functions almost instantaneously upon impact against an object offering slight resistance. This is very satisfactory when a hit is secured on any of the soft parts of a ship or on heavy armor that the shell could by no possibility penetrate; but the armor piercing properties of the shell are almost entirely sacrificed, in that an exterior explosion instead of an interior one is obtained on impact with armor that the shell would penetrate were it not provided with a non-delay fuze.

In addition to the types now in use in our service there are certain other types that have been more or less developed at different times. These may be divided into two general classes: one in which the fuze may be set at the firing point to function upon impact as either a delay or a non-delay action fuze, as may be considered most desirable by the battery commander; and one in which the action is not controlled from the firing point, but in which the fuze itself has the power of selective action depending upon the resistance encountered by the projectile in which it is assembled. The first class is hardly suitable for seacoast gun fire at long range, as the target is a ship, or at least a considerable portion of a ship, offering such a variety of resistances that there can be little hope of hitting a spot presenting the resistance considered at the time it was determined to set the fuze for delay or non-delay action. In other words, this fuze when once set is open to the general criticism of the present fuzes—that perfect action can be expected only in a certain proportion of hits, even though all the other factors may be everything that could be desired. A good example of the proper rôle for such a fuze is found in the heavy field artillery material which may be used in either open field engagements or in siege operations requiring the destruction of such objects as masses of concrete.

Two types of the selective class of fuzes offer advantages which are worthy of consideration from the standpoint of the coast artilleryman. One of these, an example of which is the Merriam fuze, is intended to delay the action of the fuze until the retardation of the projectile ceases; and the other contains both a delay primer and a non-delay primer, the non-delay

primer being fired in the usual way by the plunger of the fuze, in case a light resistance is encountered, or in case a heavy resistance is met, a shearing wire being broken or some other device operated to get the non-delay primer out of the way of the plunger and to fire the delay primer. Considering the type which acts when retardation ceases, it appears that it is theoretically about as perfect as could be desired. In the case of a light resistance, the retardation ceases almost instantly and we have non-delay action; in the case of a heavy plate, the retardation ceases as soon as the plate is penetrated and the desirable effects of delay action are obtained; and in the case of a glancing blow on armor that can not be penetrated at the angle of impact, the retardation ceases just as the projectile leaves the plate and explosion takes place after the maximum amount of projectile energy has been expended on the plate and yet while the projectile is in sufficiently close contact with the plate to insure very nearly the maximum explosive effect. Practically there appear to be no insurmountable difficulties in the making of such a fuze and a number of designs following the principle of the Merriam fuze have been suggested. In his fuze the plunger ignited the primer in the usual way; but the flame from the primer was prevented from passing into the detonator by a second plunger, or valve, which was pressed down on its seat by the retardation of the projectile. As soon as the retardation ceased the valve was lifted by the pressure of a small magazine of powder which the primer had ignited, and the shell was then exploded. The objection to the use of such a fuze in the projectile being designed is that the projectile is relatively weak, being intended for use at ranges at which there is practically no chance of penetrating heavy armor, and that therefore retardation in many cases would cease with the breaking up of the projectile and the action of the fuze would be problematical. This fuze would, however, seem to be well suited for use in armor piercing shot, which are so strong that they are not expected to break up and are primarily intended for use at ranges at which they have sufficient remaining energy to insure penetration.

The selective delay-non-delay type on light retardation differs in operation in no way from the standard non-delay fuze, and in the case of heavy retardation has all the characteristics of delayed action. With this fuze also there seems to be no great difficulty in design, except that there would be a zone intermediate between light and heavy resistance in which

there would be difficulty in predicting the action of the fuze. Whether it should be used in any given projectile depends upon the ability of the projectile to penetrate armor, which is the only thing that makes delayed action desirable. As the probability of penetration for the projectile under design is small, it is evident that delay is only occasionally desirable and that the standard amount of delay is too long and would result in poor action in the cases in which heavy armor might be struck and the projectile broken up. In this connection it is well to remember that the question of the proper fuze to use in our present stock of shell was not decided by unamimous agreement on the part of the authorities whose duty it was to make the decision, but was a compromise determined by the fact that the percentage of breakage of projectiles of old manufacture against modern armor would probably be high. As our proposed projectile has a limited capacity to penetrate armor it would seem to be a mistake to sacrifice this entirely by the use of a simple non-delay fuze as has been done with our present shell, and the writer is of the opinion that the best solution would be to use a selective delay-non-delay fuze which would function with the greatest rapidity on light resistance and have a delay less than the present standard on heavy resistance. This would give the desired non-delay on impact with masts and similar light material and sufficient delay to explode behind light armor and at least partially to penetrate intermediate armor, without having a long enough delay to permit breaking up under any circumstances without a first order of explosion or to cause explosion at a considerable distance from the plate after a glancing blow.

To sum up, it is thought that the following requirements should be met in the projectile supply for the present installed armament of the primary gun defense:

a. Projectiles purchased in the future should be of a type supplemental to the types now on hand as the available supply is so large that a general substitution can hardly be considered.

b. They should be of a lighter weight to permit a reasonable increase in range.

c. The head should be of the best practicable form from a ballistic standpoint, in order that the greatest benefit may be derived from the sacrifice in weight.

d. The charge of high explosive should be large; but the strength of the shell should not be reduced much below that of the present armor piercing shell, as all armor piercing qualities

would be lost, the projectile would be unwieldy to handle, and the fragmentation would be poor.

e. The fuze should be of a selective delay-non-delay type giving non-delay action on striking all light objects and a very slight delay action in the case of encountering objects offering more resistance.

f. The armor piercing shot now on hand should be fitted with fuzes which will function when the retardation of the projectile ceases.

g. No change should be made in the fuzing of the shell now on hand, as the percentage of breakage against modern armor will probably be high.

A projectile for the 12-inch gun designed in accordance with the above requirements will have about the following characteristics,

| | |
|---|---|
| Weight | 800 pounds. |
| Muzzle velocity | 2600 f.s. |
| Bursting charge (explosive "D") | 40 pounds. |
| Maximum range (from disappearing carriage) | 16,000 yards. |
| Coefficient of form ("Russian" formula) | .54 |

# A NEW METHOD OF OBTAINING RANGE ERRORS AT HEAVY BATTERIES BY OBSERVATION OF FIRE

By First Lieutenant HOWARD T. CLARK, Coast Artillery Corps

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Until very recently battery commanders have paid but little attention to spotting at target practice, and the making of arbitrary corrections during firing has been viewed with disfavor by the majority of artillery officers. In the last two or three years, however, opinion has changed in this respect, and spotting is used to a great extent throughout the service. The target practice regulations for the year of 1911 authorized us to install additional instruments in the base-end stations for the observation of fire; and in the January-February Journal of that year several methods of obtaining range errors were suggested, but in general, those methods are too slow or are not accurate enough for use, especially at gun batteries.

The following system was used at service practice, both battery and fire-command, in 1912, with excellent results. Although at first glance the operation may appear complicated, such is not the case, it taking but a very short time for the men assigned to the work to become thoroughly familar with it. Also, there is no more chance of blunders on the part of the operators of the apparatus used than there is in the operation of the fire control apparatus; but the officer or enlisted man who finally determines the range deviation must be able to add two or three figures of unlike signs rapidly and accurately. This part of the work may be done by the battery commander, was so done in the practices referred to, and the following descriptions are made considering that to be the case.

As the observing instrument must be to one side of the line of direction, the first thing to be considered is its location. It should be so placed that at the target the line of sight of the instrument will make a favorable angle with the line joining the battery and the target, say between 30° and 150°; or, in general, the same conditions affect the location of this instru-

ment with relation to the battery that affect the location of the secondary station with relation to the primary. At batteries that have the primary near the battery, the instrument would probably be best located at secondary; at other batteries other points might be chosen, but the point chosen must have communication with the battery by telephone.

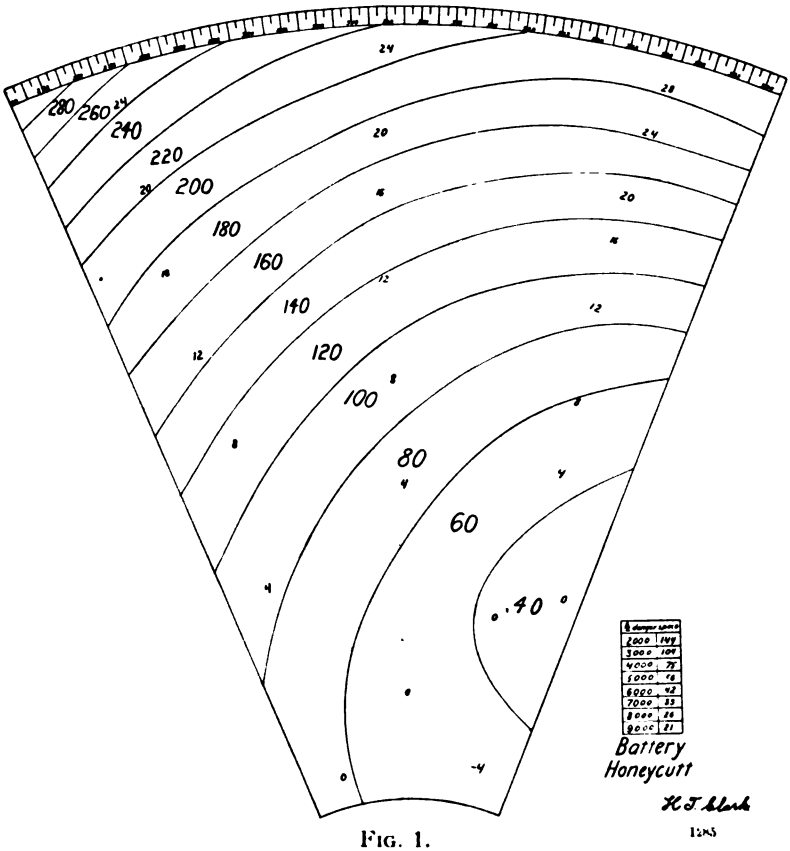



Fig. 1.

The construction of the chart shown in Fig. 1 is to be considered next. At the battery for which this was drawn the location of the instrument at the secondary station is very favorable, and the field of fire adapts itself most admirably to this method of spotting, the limiting azimuths being about forty-five degrees apart. The construction will be given considering the secondary station used; for any other location modifications may be made to suit the individual case.

This chart must give two items of information. The first is the distance along the line of direction (the line joining battery and target) subtending at the target a horizontal angle of one degree at the instrument. That is, if the angle "target-instrument-splash" is one degree, we must know for any position of the target the distance over or short that the shot falls, assuming a line shot. The second is the actual range error that exists when the angle "target-instrument-splash" is zero and the shot falls a unit distance or angle to one side of the line of direction; for when the line of sight from the instrument to the splash coincides with the line of sight from the instrument to the target (unless these lines happen to be perpendicular to the line of direction) the range error is zero only when the deflection error is zero. Having these data, the range deviation is approximately the algebraic sum of the product of the first item by the number of degrees observed at the instrument and the product of the second item by the number of units of deflection error, considering errors to one side plus and to the other minus. Now, having a clear understanding of the data desired from the chart, we are ready to make it.

It is important to remember that this is a practical discussion and not a theoretical one, the methods proposed not being based on pure theory, but having been proved in practice. The data for drawing the chart may be obtained analytically, but this is a waste of time, the best method being the following. Lay a piece of drawing paper on the plotting board, covering the field of fire. Using the gun arm as a straight edge, draw radiating lines at any convenient intervals, about every four degrees being ordinarily the most convenient. Although these lines may be drawn at random, it is better to take equal intervals. Draw radiating lines from the plotted position of the instrument. These must be drawn at equal intervals, two degrees probably giving the best results, but for clearness of description we will consider them to be drawn at intervals of one degree. At any point upon any gun azimuth line, or line of direction, we may obtain the distance along that line which subtends one degree at the instrument. These distances are obtained for all points by measuring each division of the gun azimuth line between any two adjacent instrument lines, using the scale of the plotting board, three hundred yards to the inch. Referring to Fig. 2, which is a very small portion of the field of fire, we see exactly how this is to be done. The line AB is 150 yards long, showing that if the target is at A, 150 yards is the

distance equivalent to one degree short; if at B, to one degree over. At the point U, the middle of AB, there is no appreciable error in assuming 150 yards to be the equivalent of one degree,

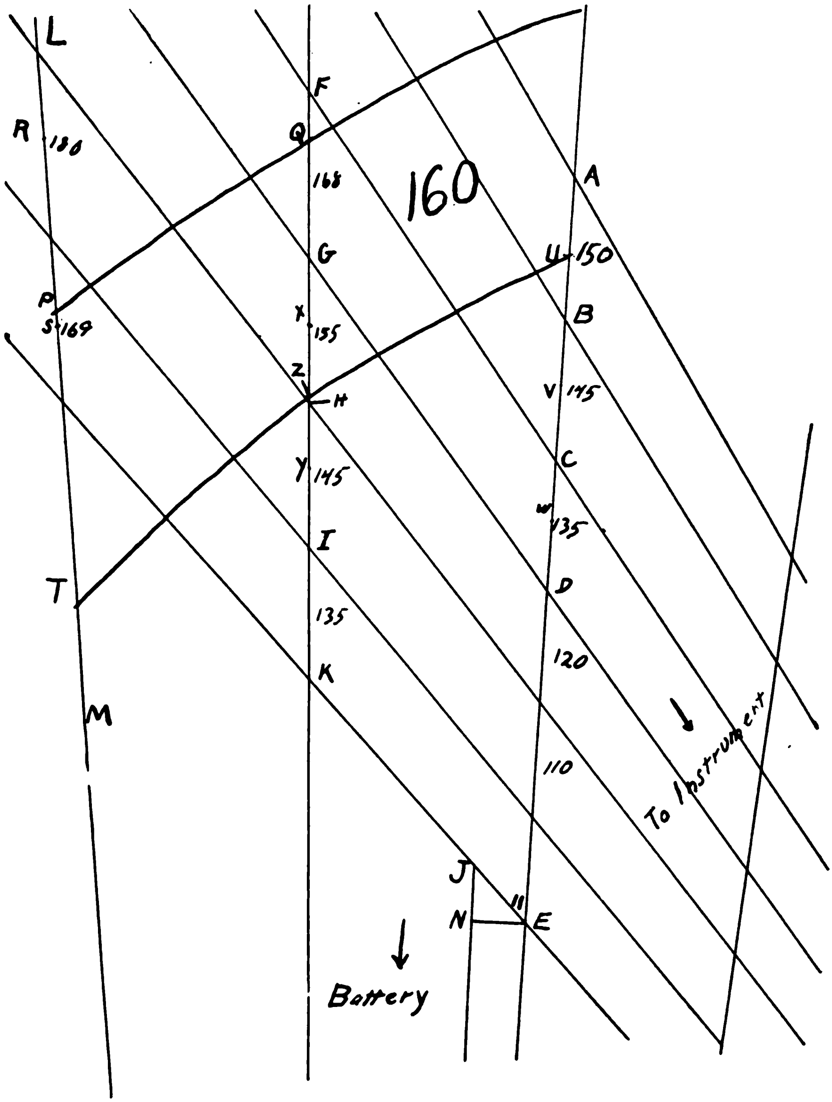



FIG. 2. 1286

either over or short. In the same way, with target at V or W we obtain the desired distance. As a most convenient way of denoting these distances on the finished chart is by zones,

we wish so to divide the chart that, knowing which zone the target is in, we see at once the required distance. To do this we determine only the points along the gun azimuth lines at which these distances are 50, 70, 90, etc., yards. Open a pair of dividers so that the distance between the points is 150 yards. Then locate all divisions approximately 150 yards long and accurately measure them. On the line FK we find that GH and HI are about this length, one longer and the other shorter. Measuring them gives a value of 155 yards at X and 145 yards at Y, X and Y being the middle points of the two divisions. Interpolating we find the exact point at which the desired value is 150 to be at Z, $\frac{5}{10}$ the distance YX from Y. U is the 150 point on AE, interpolation not being necessary in this case; and T is the point on LM. If now we connect TZU by a smooth curve, we are practically correct in stating that with the target at any point of this line the distance along the line of direction subtending an angle of one degree at the instrument is 150 yards. Similarly the 170 point on LM is 1/11 the distance SR above S or at P, on FK at Q, etc., and the line PQ is the 170 yard line. The space between these two lines is the 160 zone. In this same way the whole field of fire is divided into zones, all points near the curved lines having an equivalent of 170, 150, 130, yards, etc., all points near the middle of the zones, 160, 140 yards, etc. In drawing the curves it must not be expected that any smooth curve will pass through the exact points plotted, as it is impossible to draw the radiating lines fine enough or to scale the distances accurately enough to allow this. If, however, a smooth curve is drawn as near all the points as possible, it is a correct line.

We next wish to determine the actual range error due to a unit deflection error, when the apparent range error as viewed from the instrument is zero. First decide what unit of deflection will be the most convenient. This will depend upon the personal preference of the battery commander, that chosen for this chart being 0.10°. Again referring to Fig. 2, it is evident the value we wish to find is JN, if angle "N-battery-E" is 0.10°. The simplest method of determining this is as follows: Lay the gun arm *one degree* to the left of AE, draw EN perpendicular to the gun arm, or to JN. Measure JN to scale. This is the value for one degree, divide by ten and we have the value for the desired unit. Assume it is 11 yards; at point E write 11 in small figures. In the same manner determine the values at different points along several gun

azimuth lines, three being enough for the limited field of fire of this chart. It is not necessary actually to draw the line JN or the perpendicular EN. Lay a side of the right angle of a targ or of a triangle against the gun arm with the other side passing through E. Read JN directly from the gun arm.

For convenience of operation, on the finished chart these values are shown at 0, 4, 8, etc., yards rather that at random intervals, so interpolations should be made along the line to give the values at the desired interval. It will be noted that the amount to be added to the apparent range error is positive when the angle "battery-target-instrument" is acute; and negative, when the angle is obtuse. When the latter is the case write the value as $-4$, as shown in the lower right corner of the chart, Fig. 1.

Now, having found the required data, draw a gun azimuth circle at the top of the sheet and the paper may be used as it is, erasing the construction lines. Or a tracing may be made, copying only the zones and the figures showing the additional values to be applied to the apparent deviation to obtain the true deviation, and adding the azimuth circle.

It is evident that for the purpose of converting observed angles to yards deviation we must have some rapid means of multiplying their value in degrees by the yards equivalent of one degree obtained from the chart (Fig. 1). The table shown on the next page provides this means. The form of this will depend upon the type of instrument used for observation. The most convenient is a Scott Sight on Hagood (or similar) Mount, or the new azimuth instrument that has a movable vertical wire. Assume a sight is to be used, the normal of which is 3.00° and which reads from 0.50° on the right to 5.50° on the left to the nearest 0.05°. Then, if the normal point is kept on the target and at the instant of splash the wire is moved to the edge of the splash nearest the gun, the difference between the reading obtained and 3.00° is the angular error.

The two upper lines of the table show the sight readings. As a check the reason for which will appear later, put the "over" reference numbers in the upper line. When the observing point is to the right of the battery all numbers less than three degrees are "overs." The reading 3.00° does not appear in the table; the numbers near the center of the scale appear at the left; those near the ends of the scale at the right. It is thus seen that any two sight readings on the table, one above the other, represent the same angle. The numbers in

the left column are the numbers of the zones and lines on the chart. Any other number on the table is the product of the number at the left of its line multiplied by the number of degrees in the angle represented by the sight reading at the top of its column. For instance, assume the target to be in the 120 zone and the sight reading to be 4.60. The angle at secondary is $4.60° - 3.00° = 1.60°$, and $120 \times 1.60 = 192$. Turning to the table, on the 120 line under the reading 460 (second line from top) we find 192. The same result is obtained had we used the same zone with a sight reading of 1.40, the former, with this battery, being short, the latter over. The table, unlike the chart, may be used at any battery, merely changing about the "over" and "short" lines if necessary.

In making the table it is not necessary actually to multiply the two factors together. Along any line the difference between any two adjacent columns is one tenth the zone number. Starting at this tenth value in the second column, add another tenth for the next column, another tenth for the next one, and so on. This method gives a ready check on the accuracy of any line, as the last column may be tested by multiplication.

The table should be mounted on a drawing board with the lines parallel to the edges of the board. Make a T-square of white wood and copy the two upper lines of the table on the upper edge of the square so that as the square moves up or down along the edge of the board, the sight readings are over their proper columns. This square is not essential, but by using it blunders are less apt to be made and speed is gained.

In case the battery commander wishes to place the center of impact upon some point beyond the target, ¼ or ½ the danger space, the table shown in the lower right corner of Fig. 1 is convenient, for he will have occasion to use it, if he has any corrections to make. The chart (usually a blueprint) is mounted on a board which is large enough to allow the plotting of the directing point upon it, which is most easily accomplished by extending the sides of the chart to an intersection. At this point mount an arm similar to the gun arm of a plotting board (that is, the arm or its scale must slide in and out), and to measure the amount of motion provide a scale similar to the range correction scale.

The arm and correction scale are very easily improvised as follows. Use the arm and center furnished by the Ordnance Department for harbor charts. Fold a piece of stiff paper,

preferably white, about the arm and paste it so that a flat tube is formed that fits as tightly as possible, and yet slips along the arm. Copy on this paper the scale from a plotting board arm, the lowest reading being about 1000 yards. If now the arc of a circle (which we may call the range correction index) is drawn on the chart at 2000 yards actual range, any range correction may be set on the arm by sliding the scale along the arm until the division of the scale over the index line is the desired range correction reading. A paper clip will prevent movement of the scale after once set.

At batteries that have the plotting room directly under the battery commander's station the chart may be placed on the plotting board itself, and the above reference to mounting it on a board is unnecessary. But as this installation is the exception rather than the rule, ordinarily it will be necessary to locate the target on the chart by azimuth readings from the directing point, or near it, and corrected ranges. An azimuth instrument is set up near the directing point as a means of locating the target on the chart.

We are now ready to operate the apparatus, and we have at the observing point an observer equipped with a Scott sight on a suitable mount; and at the battery or the battery commander's station, an operator for the chart and table and an assistant to read the azimuth of the target at each bell and to assist in the plotting of the target when the operator is at the multiplying table. If possible, the operator of the chart and the observer at the sight should be in direct telephonic communication with each other; if this is impossible the messages will have to be relayed. The officer or man who totals up the different data to obtain the actual deviation uses a form similar to the following—on a pad, if used by the battery commander or some one he is willing to trust to decide what arbitrary corrections are to be made; otherwise, on a small blackboard.

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| No. of shot | Addition for deflection error + or − | Apparant range error (from table) + or − | ½ danger space − | No. of gun 2 | No. of gun 1 |
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| etc. | | | | | |

A few minutes before firing begins the target is located on the chart as follows. The range correction to be used is set on the arm. At each bell the azimuth of the target is read by the assistant and the operator lays the edge of the arm at this reading on the azimuth circle. When the corrected range is posted at the guns, he plots the target opposite this range on the arm. This is done at each bell until firing begins, after which the assistant plots the target and the operator moves over to the multiplying table. Each plotted point is, of course, the position of the target at the last bell. If the target is changing zones, the operator estimates where it will be at the splash and uses the number of this zone (or line) on his table. He places his T-square so that the zone number will appear just above the upper edge of the square. During firing the assistant keeps him informed of any change of zone.

After the observer at the instrument is notified to commence tracking, he keeps the middle of the scale on the center of the target. At each splash he moves the wire to the splash, calls out "short" when the shot appears to have struck between the battery and the target, "over" when the target appears to be between the battery and the splash, and then he reads the scale. The words "over" and "short" are not necessary, but they give the operator of the chart an opportunity to check the sight reading to a certain extent. In case "over" is called and the reading received is on the "short" line, or vice versa, he notifies the observer to check the reading. In case the reading of the splash is 3.00° the observer calls out "hit." Valuable time is saved without sacrificing accuracy if the wire is not moved and the splashes are read directly on the horn scale. (When the wire is moved, however, an assistant may check all readings by the outside deflection scale.) The observer may be directed to read to the nearest ten one-hundredths or he may read as closely as possible, the chart operator making interpolations. The former is sufficiently accurate, unless the zone numbers are very large. The table may be made to read to five one-hundredths, if desired; but it would be rather large to handle rapidly, and probably an unnecessary refinement would be introduced.

At battle or fire command practice the observer will need an assistant equipped with a watch, preferably a stop watch. Just before firing and for any material change, he is notified what the time of flight is, and he is notified at the instant any gun of his own battery is fired. He notifies the observer of the

expiration of the time of flight, and unless two shots strike within a second or two of each other there will be no doubt as to which splash to read. Ordinarily, unless other batteries are very close to his own, the observer will have no difficulty distinguishing between the reports of his own guns, as heard over the telephone, and the reports of other guns. In case the observer is not positive he is reading his own splash, he so informs the chart operator after transmitting the scale reading, so that the battery commander may decide whether or not to discard the observation.

The T-square being set as stated above, when the operator of the chart receives the data from the observer, he repeats to the battery commander (or the battery commander's assistant) "short" or "over" as the case may be, and calls out the number in the table corresponding to the reading received.

The keeper of the form shown on page (22), as each shot is fired, places a small check mark on the line showing the number of the shot, in column 5 if the shot is fired by No. 2 gun, in column 6 if fired by No. 1. At the instant of splash he obtains the deflection error in whatever manner he desires, and writes in column 2 the amount of the deviation corresponding to this error, unless it be small. In order to obtain this he observes the position of the target on the chart with respect to the *small* figures, interpolating if necessary, and multiplies the deflection error in the unit previously assumed (0.10° with this chart) by the figure taken from the chart. He records it as negative, if the deflection error and the line from the observing station to the splash are on the same side of the target; positive, if on opposite sides. (It may happen that there will be two minus signs, or a plus and a minus—for instance, if on the chart shown the target is near the lower right corner, where the figure −4 is shown. In such a case two negatives would be written positive.) The number of yards over or short, as obtained from the table, is recorded in column 3, positive if reported over, negative if reported short. The figures placed in column 4 are the half danger spaces and are always *written* negative. In case the battery commander lays his guns at a point one fourth the danger space, or other distance beyond the target, the data in this column is recorded accordingly. As the danger space does not change materially between shots this column may be filled in just before firing. As soon as all the data for each shot is received, the three numbers on that line are added together and the sum, which is the deviation referred to the

point aimed at, is placed in the column (5 or 6) previously checked. One column may be substituted for the last two, but the arrangement given shows at once whether a correction should be applied to either or both guns.

As above intimated, the construction and operation of this apparatus may appear complicated; but such is not the case. Any master gunner or the average plotter can draw the chart in a few hours, and it is very simple to mount it and provide an arm. Any man that can read a scale quickly and accurately is competent to observe the splashes after a little practice at subcaliber firing. The operator of the chart and table has less responsibility than any of the important men of the fire control section. If practicable, an officer should keep the final record; but this is not necessary, as every company probably has several men capable of doing it.

A direct telephone line from the instrument to the table is not essential, although very desirable. At the practices last year the observer gave his readings to the reader at secondary; they were transmitted by him to the secondary arm setter; called to the operator of the B. C. telephone at primary; transmitted to the operator in the B. C. station; and called by him to the operator at the table.

Firing was suspended after the third shot to obtain the first three deviations before the fourth shot was fired. With a 10-inch or a 12-inch battery this would have been unnecessary, as the information can be obtained faster than these guns can be served. With an 8-inch battery and a long time of flight it is probable that the data for any splash would not be received in time to correct the next shot of that gun; but this may not be true even with a fast gun section, if direct communication between the instrument and the table is possible. In any event, the short delay is not time wasted, and the battery commander will usually know, after his second shot data is received, whether to suspend firing after the third shot. In case he expects to interrupt the series, the gun commander should receive ample warning, so that the powder will not be inserted before the delay.

It is believed that this method, where it is applicable, will give very accurate data with sufficient speed to be used at batteries above 6-inch and with mortars. It has not been tested at rapid fire batteries, but it undoubtedly would be found to be of great value there. If the field of fire is so wide that one point of observation will not properly cover the whole

field, a second point may be established if possible, and a second chart drawn. The same table may be used, changing squares if necessary, so that all "overs" will appear on the upper line.

The results obtained at battery practice last year checked very closely with the data received by camera records, varying in the majority of cases by less than twenty yards, in one case varying seven. For the fire command practice, the majority of the shots were actually observed, there being five positive and one doubtful observation reported, and the results checked very closely with the actual "overs" as shown by the target, for those shots that struck the target. In the first practice, corrections were made after the third and fifth shots. In the second, the data was received in time to make corrections, had such been necessary.

# THE VALUATION OF RESULTS OF TARGET PRACTICE

By Major JAMES M. WILLIAMS, Coast Artillery Corps

The question of valuation of results of target practice is an important one, for by the method adopted emphasis will be given the true or an erroneous principle of controlling fire.

What is the principle underlying gunnery? That is to say, what is the principle which enables us to predict the number of hits on a given target to be obtained from a certain number of shots fired under stated conditions? That it is the mathematical principle of probabilities, no one will deny. Nor will it be denied that the same principle which enables us to predict results must be relied upon to control them. Therefore, the true principle of controlling fire that is to be emphasized in our method of valuation of results is the mathematical principle of probabilities.

How is the principle of probabilities made practical in gunnery? By consideration of the approximation of the center of impact to the target. The approximation of the center of impact to the target is, therefore, to be emphasized in our method of valuation of results.

How, during the firing of a series of shots are we to consider the center of impact? In one of three ways: by establishing means for observation of fire during practice or action; by firing a preliminary series under conditions as nearly like the conditions of the effective series as may be; or by a combination of those methods. But in any event, that upon which we are to base every action taken in the control of our fire, is the ascertained center of impact of shots previously fired. Not for one minute must we lose sight of the fact that we are considering the series of shots as a whole and are endeavoring to place the ascertained center of impact upon the target. If we adopt the second method, that of firing a preliminary series, we must remember that it is primarily and fundamentally for the purpose of ascertaining the center of impact

that is to be placed on the target during the firing of the subsequent effective series. To think and to speak of it as for the purpose of determining a muzzle velocity to be used in the solution of the ballistic problem presented by each shot of the subsequent series regarded as an isolated experiment, is misleading; for at once we are likely to believe that we may to advantage introduce a correction without regard to the center of impact and with the sole idea of getting the *next shot* nearer to the target. To do that is to abandon our principle—to be led away from a consideration of primary causes by regard for secondary effects: the muzzle velocity has no value that is not derived from the center of impact on which it is based.

How are we to emphasize in the valuation of results of practice the importance of approximation of the center of impact to the target? By ignoring the chance falling of individual shots—by turning away our eyes from the deceptive "splash" and by valuing the performance according to the position of the invisible representative of our principle.

Are we then to make use of the center of impact of the "splashes" for the purpose of determining the merit of our performance? No; our problem is a complex one and must be analyzed.

There are three primary elements concerned in our performance: the system of gunnery, or fire control; the matériel; and the personnel. Each is on trial; and the part played by each must be determined, for the object of our practice is to learn and to progress.

The first requisite for an analysis of practice is a trustworthy record; and to obtain that each officer must be impressed with the fact that target practice is primarily, not a competition, but a scientific experiment, the record of which is nothing more nor less than a test sheet. He is taking part in the solution of a great scientific problem and any error that he permits to creep in will result in a certain degree of failure; and that failure, for all he can tell, may be manifested at a future day by the conquest of his country and the subjugation of his people. In target practice as well as at Trafalgar every man is expected to do his duty.

It is proposed to analyze the reports of practice, separating the errors of personnel from those of matériel, and then to value the results by the approximation to the target of "the center of impact for matériel" so corrected that every error of operation committed by the personnel, whether it caused a

splash to fall farther from the target or nearer to it, shall be counted in a direction away from it. And at the same time that the reports are analyzed for the purpose of determing that corrected center of impact, which may be called "the center of impact for efficiency," there will be determined also the work of each gun or mortar, as well as the degree of approximation of "the center of impact for matériel" to the target which resulted from the system of gunnery.

Because of the very great use we make of mechanical means of solution of ballistic problems, it is deemed of especial importance that our method of reporting the results of practice be such that errors of operation shall be uncovered. In one case of mortar practice that has come to the writer's attention, the battery commander, after submitting his reports of practice, still believed that his poor showing had been caused by a supposed erratic course of the target; whereas, analysis of the results to determine the approximation to the target during record practice of the center of impact determined by the trial shots, and the accuracy of operation in solution of the ballistic problems by the fire control section, showed that the approximation of the center of impact, unaffected by errors of operation, was excellent, but that the work of the fire control section had been extremely inaccurate, the inaccuracy being due, obviously, to a constant error in the setting of the elevation scale of the mortar arm on the plotting board: the correction to be made as a result of the trial shots had evidently been set off in the wrong direction.

The practice just cited illustrates very clearly the misleading effect of scoring by hits, there being scored as hits in that practice shots for which penalties should have been imposed because of gross errors of operation in obtaining data for them. In one instance, there was scored as a hit a shot* in the elevation for which was an error of −133 yards made by the fire control section; that is to say, the elevation determined corresponded in the range table to a range 133 yards shorter than the corrected range to the target, while the range attained was 90 yards greater than the expected range; but the shot scored as a hit for one of two reasons: the elevation setter did not set the elevation determined; or the shot was an erratic one, due to variation in powder or meteorological conditions. In the entire record practice, the mean difference between the corrected ranges determined and the ranges corresponding in

* See first record shot, form for range, at the end of this article.

the range table to the elevations determined was −134 yards; that is to say, had the center of impact for matériel been on the target, the center of impact for splashes would, owing to faulty work by the fire control section, have been 134 yards short of the target; yet the battery received a positive figure of merit. In another mortar practice were scored as hits two shots in which were made by the fire control section alone errors of −51 yards and −76 yards respectively.

As regards the system of gunnery, the cases here cited afford evidence of the efficacy of the system which has as its object placing upon the target the center of impact of a series of trial shots; for in the first case referred to, had the center of impact determined for the trial shots been on the target during the record practice, seven of the ten shots would have fallen within fifty yards of the target;* and in the second case, under like circumstances, six of the record shots would have so fallen.

To be content in target practice with a scoring of splash hits, or even with an approximation to the target of the center of impact of the splashes, irrespective of whether obtained through erroneous work, is equivalent to basing our hope of hitting in action upon an expectation of repeating in action the errors made in practice: whereas, our object should be to uncover errors made in practice to the end that they may not occur in action.

In brief, the method of valuing results proposed, considering the range problem and the deflection problem separately, is for each: (1) to free the record of each shot fired of all error of personnel so far as practicable; (2) to determine, relatively to the target, the center of impact of all shots when thus freed of errors of personnel; (3) to find the *arithmetical* mean of all errors of personnel committed in the series; (4) to apply that arithmetical mean to the center of impact determined in (2) in such a manner as to move the center of impact still farther from the target; (5) to determine the score by the corrected center of impact found in (4).

For the purpose of analyzing the practice and determining the longitudinal (range) and the lateral (deflection) coordinates of "the center of impact for efficiency," are presented two forms, applicable to mortar fire, one for the range problem and one for the deflection.

From the forms it will be observed that, for purposes of valuation of results, no distinction is made between trial shots

* See column 15, form for range, at the end of this article.

and record shots, the accuracy of operation incident to each affecting the "efficiency center of impact." And while that may impress one at first as unusual, a little consideration will convince one that it is not only just, but, as a matter of fact, not at all different from our present practice, under which a distinction is apparent only because we treat trial shots in record form, while counting record shots as hits or misses on a hypothetical target. If we treat all in record form, the distinction disappears.

Referring to the form for the range problem, the first error considered is found to be the algebraic difference between the correction indicated by the camera record of the trial shots and the correction used for the first record shot, based on the trial shots. For convenience in the sequence of columns, this error, though first in order of occurrence, appears in column 19.

The second error is that of prediction in range. It appears in column 5.

The third error is that incident to determination of the elevation, and it appears in column 10.

A fourth error may be incident to an attempt at correction from observation of fire during the record shots, and provision is made for it in column 18. However, in order that battery commanders may not be discouraged from making corrections from observation of fire where circumstances warrant them, columns 15, 16, 17, and 18 have been so designed that their effect is to allow credit for a just correction, at the same time that they penalize an undue correction.

In column 14, as well as in column 19, the camera record has been taken as the criterion for scoring purposes, because we desire the most accurate standard available: not only the personnel and the matériel, but also the system of gunnery is under test; if any one of the three elements does not measure up to the standard, it should be discovered.

The algebraic mean of the entries in column 15 determines the approximation to the target of the "center of impact of pit sections and matériel" for range.

In column 24 are found the total errors of operation; and in column 25 appear the same errors either increased or diminished as a result of corrections made from observation of fire. The arithmetical mean of the entries in column 25 determines the approximation to the target of "the center of impact of the fire control section personnel" in range.

In column 26 are combined the errors of the pit sections

and the matériel with those of the fire control section personnel, the combination being made in such a manner that the mean of the entries in column 26 represents the range coordinate of the "center of impact of pit sections and matériel" referred to the target, increased by a distance equal to the mean error of the fire control section. This modified range coordinate of the "center of impact of pit sections and matériel" represents the range coordinate of the "efficiency center of impact"of the battery as determined in the practice reported.

The effect of thus determining the coordinate of the "efficiency center of impact" is to charge the battery with every error of operation committed, at the same time indicating the efficiency of the materiel as cared for by the personnel. The method of valuation includes a thorough analysis of the practice, so the battery commander necessarily learns what his mistakes have been.

For deflection, the form is similar to the form for range. The errors of the fire control section are found in columns 5, 12, 20, and 21; and the errors of the pit sections and the matériel in column 17. The latter, however, are not freed of variations due to wind, etc.

The proposed forms afford not only a means of valuation of results and an analysis of errors made, but also a ready indication of the work of the separate pits and the individual mortars. (See columns 20-23 on the form for range, and columns 22-25 on the form for deflection.)

While the forms are large as compared with Form 819B used in 1912, their preparation demands the recording, at the time of practice, of only one additional item of information, that being the azimuth of the target at the instant of splash (column 4, form for deflection). With that exception, the increase in the size of the form, it being incidental to the analysis of the practice, which is done afterwards, involves no additional labor during the practice.

The means of valuation of results is afforded by the algebraic mean of column 26 of the form for range and the algebraic mean of column 28 for deflection; those mean values being used as the longitudinal and lateral coordinates respectively of the "efficiency center of impact," referred to the target. The mean of the entries in column 28, form for deflection, being expressed in degrees, must be reduced to its equivalent in yards at the mean range of the practice.

The system or scale of values for different positions of the

"efficiency center of impact" might be fixed according to the present circular target for mortars or according to "probable rectangles."

If the circular target be adhered to, describe about the plot of the target circles of radii from 10 to 50 yards, the difference between successive radii being 10 yards. If the plot of the "efficiency center of impact," determined as above, falls within the circles so drawn, subtract from 110 the number which represents in yards the radii of the smallest circle in which it does fall, and the remainder will represent the score in hitting efficiency on a scale from 60 to 100, in which nothing less than 60 is considered. The element of time may then be introduced for the purpose of determining a figure of merit according to present custom.

If a series of probable rectangles be preferred to a series of circles, it can be very conveniently substituted therefor. In this case the hitting efficiency would be obtained by subtracting from 100 the number representing the probability percentage of the smallest rectangle in which the "efficiency center of impact" falls.

The advantage of the method herein proposed for scoring is that errors are not permitted to compensate, but each and every one made detracts from the score. The element of chance is eliminated and battery commanders must recognize that "their sins will find them out."

In the forms as here presented have been entered the data of a practice actually held, the practice, in fact, referred to on page 29. The mean of column 15 (form for range) and the mean of column 17 (form for deflection) show how excellent the practice would have been had the center of impact determined in the trial shots been placed on the target in the record shots: the center of impact of the entire practice would have been 11 yards short of the center of the target and 0°.06 to the left of it. Whereas, the mean errors of the personnel were 116 yards and 0°.07.

Comparison of 163 yards and 0°.56, the dispersion in range and deflection indicated respectively in column 20, form for range, and column 22, form for deflection, when considering all shots fired from three mortars in each of two pits, with 88 yards and 0°.19, the maximum dispersion in range and deflection indicated respectively in column 22, form for range, and column 24, form for deflection, when considering only shots fired from the same mortar, suggests consideration of the

question whether our system of grouping mortars for control is wise. The dispersion in range is almost double and the dispersion in deflection almost treble. Comparison of the deflection errors of the mortars of the two pits, column 24, form for deflection, shows the maximum dispersion of a mortar to have been 0°.19 in each; whereas an examination of the entries in column 15, form for deflection, shows that, consistently, with the single exception of the comparison of the fifth and the sixth shots, "B" pit, the left pit, fired about 0°.20 further to the left than "A" pit when the target was going from left to right, and about 0°.36 when it was going from right to left.

In fact, the figures in the form for analysis are eloquent, as well regarding the system of fire control as regarding the matériel and the personnel.

A form for the analysis and valuation of the range problem in the case of guns has been prepared, and differs from that in the case of mortars chiefly in such respects as are incident to the use of the range board. A careful analysis of the deflection problem for direct fire guns, under our present method of solution, is, perhaps, impracticable. But, on the other hand, so long as the solution is satisfactory, analysis is not imperative; while it would be very simple to devise a "by-the-numbers" solution to be employed in the case of organizations showing the need of it, which would render analysis practicable.

(To face page 34.)

| Number of shot. | Tactical designation of mortar. | Range to set forward point | Numerical sum of entries in columns 5, 10, and 19, which represents total of errors of operation in determining data for each shot, affected with plus sign in all cases. | Algebraic sum of entries in columns 18, and 24, which represents total error of operation either increased or diminished by correction from observation of fire. | Algebraic sum of entries in columns 15 and 25, the latter affected in each case with the sign of the mean of column 15. |
|---|---|---|---|---|---|
| 1 | 2 | | 24 | 25 | 26 |
| T1 | A3 | 3 | + 15 | + 15 | − 20 |
| T2 | A3 | 3 | + 15 | + 15 | − 43 |
| T3 | A3 | 3 | + 15 | + 15 | − 4 |
| T4 | A3 | 3 | + 15 | + 15 | + 1 |
| 1 | A1 | 3 | +156 | +156 | − 66 |
| 2 | B1 | 3 | +151 | +151 | −227 |
| 3 | A2 | 3 | +154 | +154 | −171 |
| 4 | B2 | 41 | +174 | +174 | −208 |
| 5 | A3 | 38 | +152 | +152 | −121 |
| 6 | B3 | 37 | +155 | +155 | −142 |
| 7 | A1 | 37 | +143 | +143 | −141 |
| 8 | B1 | 37 | +185 | +185 | −223 |
| 9 | A2 | 36 | +152 | +152 | −197 |
| 10 | B3 | 36 | +144 | +144 | −216 |
| Mean, alg | | | | +116[b] | −127[a] |

* Make n

† Assume

‡ No cam

# A TIME-AZIMUTH BOARD FOR MORTARS

By Captain ALBERT C. THOMPSON, Jr., Coast Artillery Corps

This board is 8 feet long by 5 feet high. At the top is given a series of azimuths representing each degree in the field of fire and arranged in five horizontal lines as shown. A horizontal ruler with counterweights is provided for covering up the lines of azimuth not in use.

The board is divided into cross sections, by painted white lines. Three inches on the horizontal lines represent one degree of azimuth and three inches on the vertical lines represent one predicting interval.

Scales are made for the different weight projectiles As the principle is the same for each and these scales differ only according to the different drift of the projectiles, the one for the 1046 pound projectile only will be described here.

This scale is on the same scale as the board and has the normal 2.63 degrees (taken from the range tables) to the right of the point marked 45 degrees, and to the left of this latter point degrees of elevation up to sixty-five are marked and subdivided as on the mortar deflection board. This scale may be called the Elevation Scale. A movable pointer is placed on the scale, and graduations are made to the right and left of the normal for arbitrary corrections.

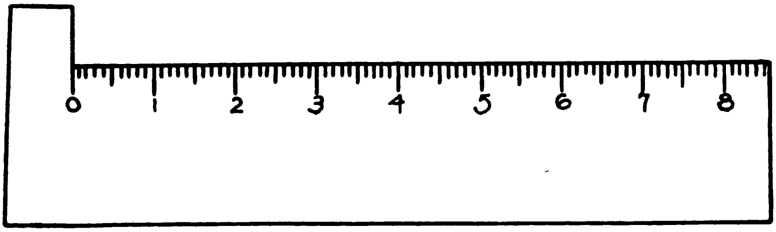
The operator of the Time Azimuth Board wears a head set connected to the Battery Commander's data phone.

The true azimuth of the first set forward point is sent to him on the Battery Commander's line just ahead of the predicted point. This is not repeated by the telephone operator in the Battery Commander's Station, who also hears it. A point corresponding to this set forward point is located on the first horizontal line. The pointer on the elevation scale is set at this point. When the elevation appears at the booths, the operator locates a point on the first horizontal line corresponding to it. This point should closely approximate the corrected azimuth of the set forward point shown at the booth; which

point is also plotted on the board. If it does not do so, "Relay" should be given.

The next set forward point is located on the second horizontal line, and so on, until the bottom of the board is reached. After that, the next point is placed at the top line and plotting continued as before.

The series of points representing the true azimuths, when joined by a line, will give a regular curve. The corrected azimuths, when joined, will not.

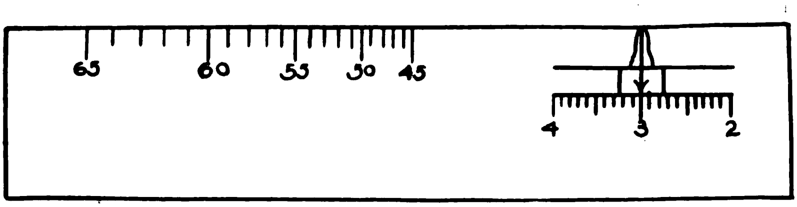



TRAVEL SCALE (RIGHT) 1287

Travel scale (left) can be placed on opposite side

It will be seen then that this is a complete check on the data sent to the booths and on the plotting of the position of the target.

This has been tried for several weeks at Battery Key, first on cross section paper and then on the board described, and it is found that errors are detected in sufficient time to prevent firing and that it does not interfere with the regular fire control work.




ELEVATION SCALE FOR 1046 POUND PROJECTILE 1288

The board is located against the side of the Battery Commander's Station, where the operator can see the boards in both pits. For the use of this board, but one man, a head set, and two lights for night drill, are required.

The board was designed by Corporal August P. Diehl, of the 103rd Company, Coast Artillery Corps.

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 280 | 281 | 282 | 283 | 284 | 285 | 286 | 287 | 288 | 289 | 290 | 291 | 292 | 293 | 294 | 295 | 296 | 297 | 298 | 299 | 300 | 301 | 302 | 303 | 304 | 305 | 306 | 307 | 308 | 309 | 310 |
| 300 | 301 | 302 | 303 | 304 | 305 | 306 | 307 | 308 | 309 | 310 | 311 | 312 | 313 | 314 | 315 | 316 | 317 | 318 | 319 | 320 | 321 | 322 | 323 | 324 | 325 | 326 | 327 | 328 | 329 | 330 |
| 320 | 321 | 322 | 323 | 324 | 325 | 326 | 327 | 328 | 329 | 330 | 331 | 332 | 333 | 334 | 335 | 336 | 337 | 338 | 339 | 340 | 341 | 342 | 343 | 344 | 345 | 346 | 347 | 348 | 349 | 350 |
| 340 | 341 | 342 | 343 | 344 | 345 | 346 | 347 | 348 | 349 | 350 | 351 | 352 | 353 | 354 | 355 | 356 | 357 | 358 | 359 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |

Another method of check, which was tried but abandoned for the foregoing, is as follows.

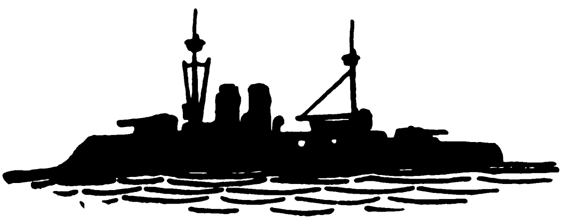
On the assignment of a target, the travel was secured from the Battery Commander's instrument and when the data for the first prediction appeared, the corrected set forward point was located on the first horizontal line, directly under the azimuth shown at the top of the board. If the target was traveling to the right, the right side of the travel scale was then placed with the vertical edge, or zero, at this point and the travel was set off to the right on the second line to a distance corresponding to the travel of the target in one predicting interval. A point was here located on the second line which should be the azimuth of the second prediction if the elevation remains the same as for the first prediction. If it does not remain the same, take the elevation scale; place the elevation corresponding to that of the previous prediction at the point located on the second line, and as soon as the elevation is shown at the booths, locate a point on the second line at the new elevation, which is the azimuth of the second prediction.

In case the plotted azimuth is less than that shown at the booths, it shows that the travel used was insufficient or that the target had increased its speed. If the plotted azimuth is greater, the contrary is the case.

For the third prediction, place the travel scale on the correct azimuth of the second prediction, and proceed as before, increasing or diminishing the travel as found necessary.

This method contemplates obtaining the travel only at the start from the B.C. instrument. Any sudden change of travel greater than the ordinary increase or decrease of speed in the target would indicate error.

The first method, now in use here, is considered much superior, and the latter is given only as a method which accomplished its object, but has been superseded in a "process of evolution."



# NOTES ON SPOTTING

By 2nd Lieutenant LEVIN H. CAMPBELL, Coast Artillery Corps

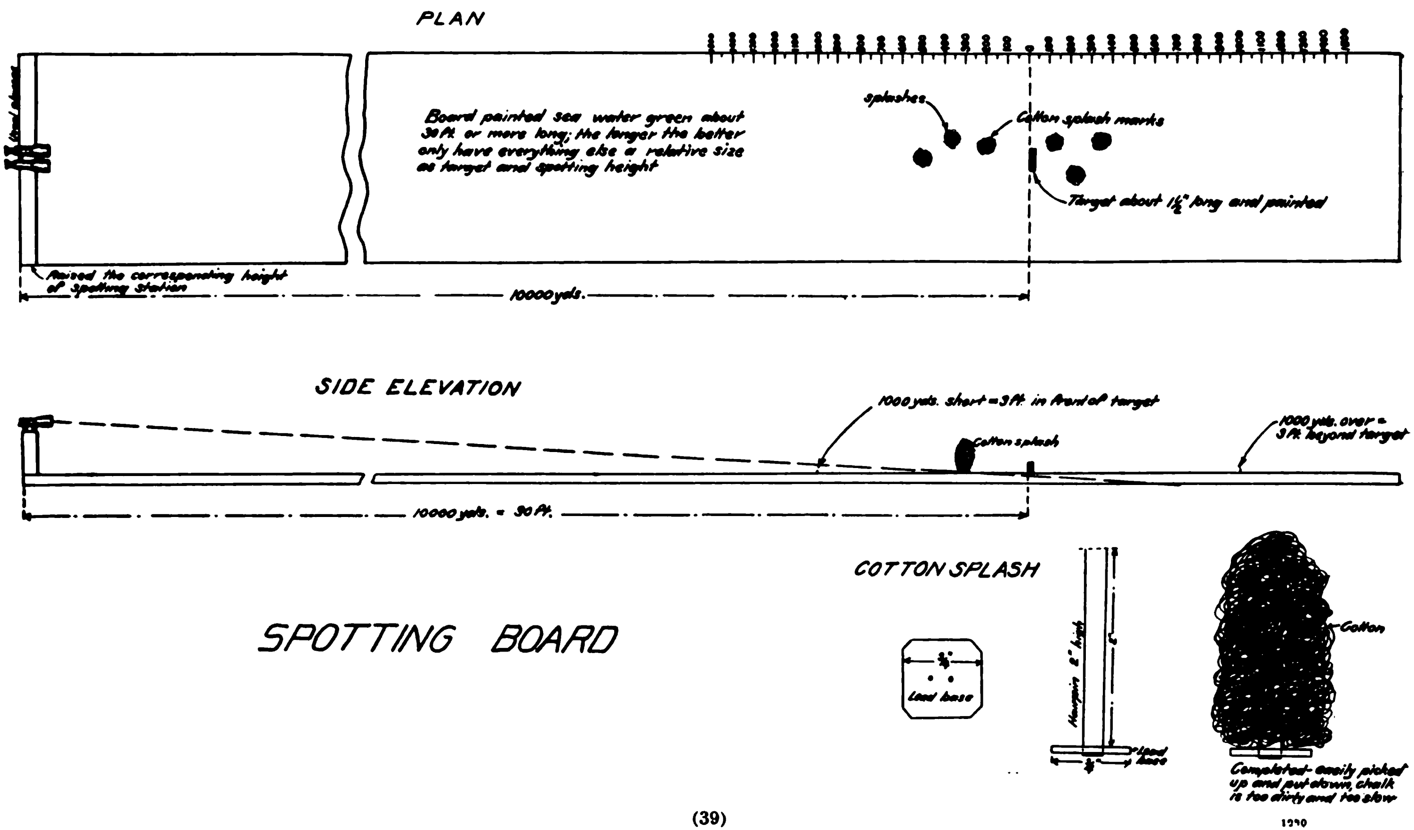
Artillery Bulletin No. 94, Serial No. 105, prescribes a system of "Fire Control for Rapid Fire Batteries." In this system "spotting" is provided for. As this work will devolve on the lieutenants of the companies, the writer feels that a few remarks on the subject may assist those officers.

During the target practices of the 155th (Mine) Company for the season of 1912, I spotted for the battery firings; but as the system used by the battery commander closely resembles that prescribed in the bulletin, I will not describe it in detail.

We may well consider first how the training may be obtained to enable an officer to spot. The method given is that used in the United States Navy.

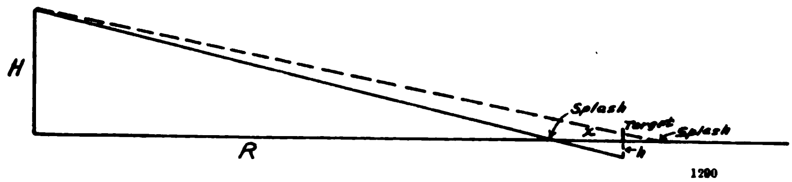
A spotting board similar to the sketch (which shows a board for major caliber guns) can be easily made and used in any barracks. A strip of floor about four feet wide and twenty-five feet long is painted a sea-green color. A piece of painted canvas is equally good. The scale used is 3 feet = 1000 yards for major calibers, and 1 foot = 200 yards for 3-inch R. F. guns, so that a range of 4000 yards actual will give a range of twenty feet on the board. The range differences at the target may be marked on the strip as shown. The miniature target used is 1 inch high and 2 inches long. The cotton splashes consist of a lead or wooden base painted white, with a hairpin passing vertically through and carrying a wisp of cotton. These splashes are about ½ inch high. The spotter should ascertain the height from which he is to spot during actual practice. This height, reduced to suitable scale, is the height of eye used with the board.

In operation, the target is placed at, say, 4000 yards by an assistant; the spotter looks through his glasses; and another assistant puts a shield over them to cut off his view. The first assistant puts a "splash" down in front of the target, or in rear and in line with one of its edges, the shield is removed from the glasses for fifteen seconds and then replaced. The




SPOTTING BOARD

spotter, from his observation, calls, "Up 50" or "Down 100," or whatever the correction is. This correction is obtained from a spotter's table, which can easily be memorized. The table is worked out for different ranges from similar triangles as follows:




$$H : h : : R : x, \text{ from which, } x = \frac{Rh}{H}$$

$H$ = Height of eye in inches, using the board; in feet, in service.
$h$ = Vertical distance in inches the "slick" of the splash appears to be under the target or up the side of it, using the board.
$R$ = Range to target in yards.
$x$ = Range correction in yards, up or down.

The dotted lines show the quantities of the proportion in the case of an "over."

From this it is seen that a slight discrepancy exists in the proportion, which should be $H : h : : R+x : x$. This, however, introduces an error considerably less than that with which a "spot" can be expected to be made. The spotter's table is of this form:

| Range 3000 yards | | Range 3500 yards | |
|---|---|---|---|
| Splash under target | Correction yards (+) | Splash under target | Correction yards (+) |
| 4 | 125 | | |
| 3 | 100 | | |
| 2 | 75 | | |
| 1 | 50 | | |
| 0 | Hit | | |
| Over target | Correction yards (−) | Over target | Correction yards (−) |
| 1 | 50 | | |
| 2 | 75 | | |
| 3 | 100 | | |
| 4 | 125 | | |

The figures given are merely for illustration, as they vary with the height of the eye. The ranges for which the table is made out are sufficiently close together so that an appreciable change in correction for a given distance of splash under or up the side of the target will be shown. In making out the table for service practice, it is well to add $\frac{1}{8}$ the danger space for the range to all "shorts," and to subtract a like amount from "overs."

In spotting, the observer should always think of the "slick" of the splash as being vertically under the waterline, or vertically up the side of the target. For the spotting board, the table should be made out for vertical inches, and for service practice for vertical feet, under the target or up its side.

After the spotter has become proficient in using the board, that is, in quickly estimating "overs" and "shorts" at various ranges, he should practice spotting for subcaliber firing. With the small subcaliber projectile used in 3-inch R.F. guns this is not practicable with advantage to the training, on account of the small splash and no "slick." At posts where guns of major caliber are firing subcaliber, the spotter can profitably practice spotting the shots. He should, if possible, select a position directly in rear of the battery. The elevation should approximately equal that of the spotter's station for his own battery. The range used approaches the range at which his battery will fire, and the splash is enough to observe on. By "slick" is meant the apparent white line passing through the center of the splash.

After considerable practice of this nature, the spotter should be competent to lend valuable assistance to his battery in firing.

For the rest, the system used at Battery Keyes in the season of 1912 will be explained. I was stationed in a house tower, elevation 114 feet, directly in rear of and about 150 yards from the battery. A telephone line connected me directly with the battery commander, who controlled the firing of his battery by electric gongs. The command "Commence Firing" was given; by prearrangement one shot was fired; I spotted this shot and gave him the correction immediately. This was applied at the guns, another shot was fired, my correction, if any, was applied, and the firing then taken up as fast as possible. If at any time during the firing I saw that the guns were getting off the target, I gave my correction, the battery commander ceased the fire by means of the gongs, the correction was ap-

plied, and the firing resumed. It may appear that too much time is lost at the first shot. This however, is not the case, as a correction may be applied and firing resumed within three or four seconds after the first shot strikes.

For night firing, the spotter will find that he must take a position so that he will not see the direct flash of the guns. The higher the power of the glass used, the better. It is well to have a glass fitted with a very fine horizontal cross-hair, and to rest the glass on a stationary object. The greater the height of the spotter's station, the more accurate will be the "spots."

In conclusion, "spotting" is the estimation of the apparent vertical distance of the "slick" under the waterline of the target, or up the side of the target, and a rapid mental transformation of this distance to horizontal yards short or over.

# ADJUSTMENT OF FRICTION DEVICES

By 1st Lieutenant CHARLES L. WILLIAMS, Coast Artillery Corps

Fig. 1 shows the principle of a scheme, as applied in the case of a 10-inch disappearing carriage, Model 1896, for adjustment of friction devices under the provisions of Circular No. 13, War Department, 1910, as amended by General Orders No. 3, War Department, 1912.

The scheme is to employ a lever of the "second kind," having the *fulcrum* formed at one end by attaching the lever, by means of a chain, to the large rear transom frame of the chasis; having the *weight* (the frictional resistance) attached by means of a second chain, two feet from the first, connecting the lever to the upper cross brace of the elevating arm; and having the *power* (in the form of a weight) applied by means of two 10-inch projectiles at the other end of the lever. The ratio of the arms must, of course, be carefully calculated, the weight of the lever and its attachments being considered in the calculation.

It is believed that this method has the advantage of simplicity of apparatus, availability of material, and accuracy of result.

The material for constructing the shackles shown at A, B, and C in Fig. 1 can be picked up from the scrap heap of any ordnance machine shop. The entire apparatus illustrated was gotten ready for use in one morning, utilizing a standard Ordnance Department 8-inch × 8-inch × 192-inch timber, Ordnance Department chains for slings and attachments, and scrap parts for shackles. A little forging and the boring of a few holes for pins, was all the work required.

Accuracy of result is due to the practical elimination of friction through the employment of chains as the means of attachment of the lever to the fulcrum and to the weight.

The scheme conforms to the requirement that the prescribed number of hundreds of pounds weight shall be applied to the elevating arm; for, though a strict interpretation might

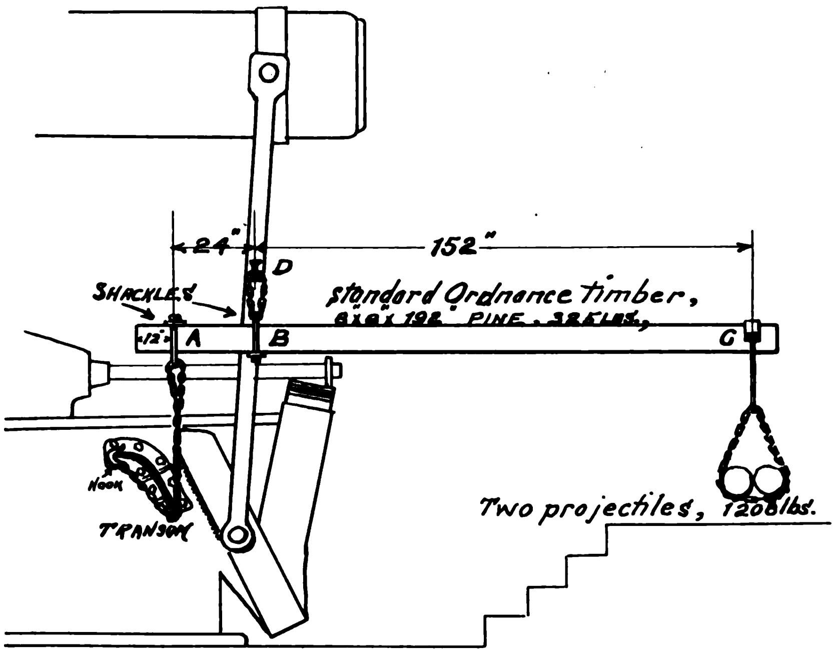



FIG. 1. 1291

Scheme for applying weight to elevating arms of disappearing carriages, to ascertain the correct setting of friction device, as required by Circular 13, W. D., 1910, as amended by G. O. 3, W. D., 1912.

To adjust for different carriages, shift shackles A and C. Position shown is for 10-inch D.C.,L.F., Model of 1896, giving 10,000 pounds pull on elevating arm at D.

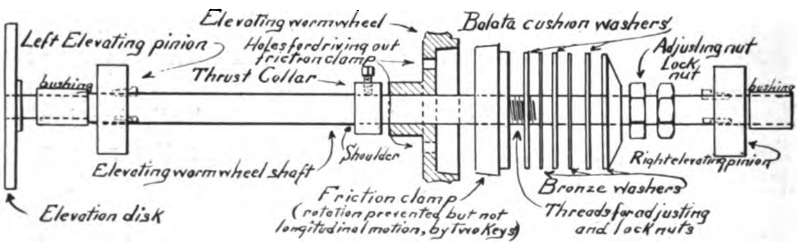



FIG 2. 1292

Friction device of elevating mechanism. 10-inch D. C., L. F., Model of 1896

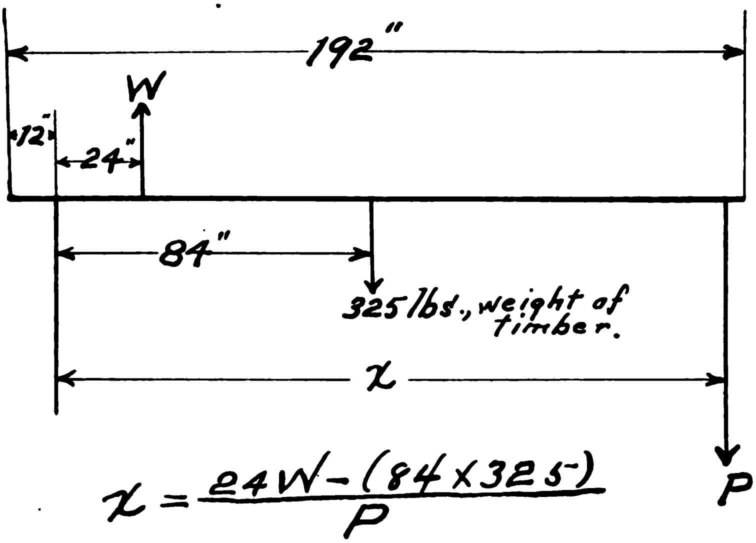
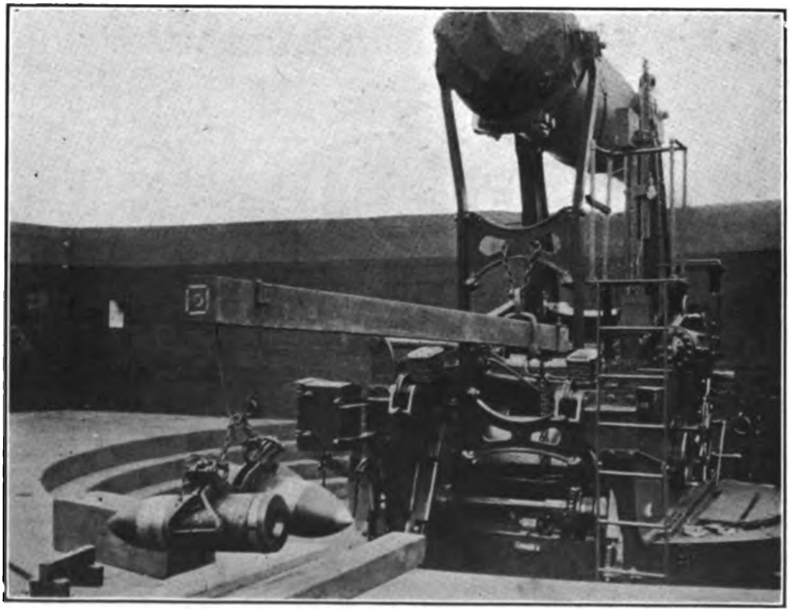



FIG. 3. 1293

P = two projectiles



1294

seem to require that an actual weight of so many pounds shall be hung on the arm, yet if a *downward pull* be applied to the prescribed part by means that enable one to gauge accurately the prescribed number of pounds, the intent of the order is carried out. Accuracy precludes the use of block and tackle; because with it the value of friction is too great to be disregarded, while very difficult of accurate determination. For a similar reason utilizing the gun itself as a lever by applying the power at the muzzle is inaccurate—the friction of the trunnion bearings is unknown.

In Fig. 2 are shown the details of the friction device of the elevating mechanism of the 10-inch Disappearing Carriage, L. F., Model of 1896.

In Fig. 3 is presented a diagram of the lever with relations indicated.

# COAST DEFENSE IN THE CIVIL WAR*

## ATTACK ON ROANOKE ISLAND, NORTH CAROLINA
February 7 and 8, 1862

By 1st Lieut. WALTER J. BUTTGENBACH, Coast Artillery Corps

### General Situation

This expedition was proposed by General Burnside for the purpose of establishing a lodgement on the southern coast and penetrating into the interior, thereby threatening the lines of communication in the rear of the main Confederate army then concentrating in Virginia. It had also as an object holding possession of the inland waters of the Atlantic Coast. It finished the work begun when Hatteras Inlet was taken.

### Special Situation

It was decided to drive the Confederate forces off Roanoke Island, capturing the works they had erected there after they were deprived of the works at Hatteras Inlet.

### Opposing Forces

#### CONFEDERATE

The Confederates† had erected the following works:

Fort Bartow, a sand fort, heptagon trace, covered with turf and located on Pork Point on the west side and in the northern half of Roanoke Island. In it were mounted

6 32-pounders, in embrasure;
3 32-pounders, in barbette.

It was said to contain also one 7-inch Parrott gun, and it was protected in rear by a field battery.

* See note to "Coast Defense in the Civil War, Fort Sumter, S. C. (First Attack)," in Journal U. S. Artillery, March-April, 1912.

† Roanoke Island in February, 1862, was in a military district commanded by Brigadier-General Henry A. Wise, C. S. A., and attached to the Department of Norfolk, commanded by Major-General Benjamin Huger, C. S. A. During the engagement of February 7th and 8th the immediate command devolved upon Colonel H. M. Shaw, 8th N. C. Infantry. Major G. H. Hill, C. S. A., was in command of Fort Bartow.—*The Editor.*

Fort Blanchard, a semicircular sand fort covered with turf, situated on the same side of the island, one and a half miles north of Fort Bartow. In it were

4 32-pounders, in barbette.

Fort Huger, a sand work covered with turf, at Weir's Point about a mile or three quarters of a mile north of Fort Blanchard and on the same side of the island. In it were mounted

8 32-pounders, in embrasure;
2 32-pounders, rifled, in barbette;
2 32-pounders, in barbette.

The rear of the fort was closed by a breastwork provided with banquette for infantry.

A small work at Midgett's Hommock, on the east side of the island, about three miles from Fort Bartow. It contained

2 32-pounders, in barbette.

A redoubt, in the center of the island, about two miles southeast of Fort Bartow and about a mile and a half southwest of Midgett's Hommock. This redoubt was some seventy feet long, and was across the only road running from Ashby's Harbor to the northern end of the island. It contained

3 field guns.

Fort Forrest, at Redstone Point, on the mainland, across Croatan Sound and nearly opposite Fort Huger. Here were mounted

7 32-pounders.

Besides the land forts, the Confederates had a small "floating" battery, grounded above Redstone Point, which carried seven small 32-pounder guns, and a flotilla of about eight small gunboats, mounting one or two guns each.

There had also been prepared a barrier of piles and sunken vessels to obstruct the channel of Croatan Sound just above Fort Bartow.

The Confederate garrison on the island, besides the manning parties of the forts, consisted at first of some 1024 men; but they received reinforcement during the fight, and the maximum total is estimated to have been several thousand.

### FEDERAL

The Federal forces, army and navy, engaged in the attack, consisted of naval vessels, armed War Department vessels, and troops, as follows:

Naval Vessels

| | |
|---|---|
| *Philadelphia* | 2 12-pounders; |
| *Stars and Stripes* | 4 8-inch guns, |
| | 1 20-pounder rifle, |
| | 2 12-pounders; |
| *Louisiana* | 1 8-inch gun, |
| | :32-pounders, |
| | 1 12-pounder; |
| *Hetzel* | 1 9-inch gun, |
| | 1 80-pounder rifle; |
| *Underwriter* | 1 8-inch gun, |
| | 1 80-pounder rifle, |
| | 2 12-pounders; |
| *Delaware* | 1 9-inch gun, |
| | 1 32-pounder, |
| | 1 12-pounder; |
| *Commodore Perry* | 1 100-pounder rifle, |
| | 4 9-inch guns, |
| | 1 12-pounder; |
| *Valley City* | 4 32-pounders, |
| | 1 12-pounder; |
| *Commodore Barney* | 4 9-inch guns, |
| | 1 32-pounder, |
| | 1 12-pounder; |
| *Hunchback* | 3 9-inch guns, |
| | 1 100-pounder rifle; |
| *Southfield* | 3 9-inch guns, |
| | 1 100-pounder rifle; |
| *Morse* | 2 9-inch guns; |
| *Whitehead* | 1 9-inch gun; |
| *Lockwood* | 1 80-pounder, |
| | 2 12-pounders; |
| *Henry Brinker* | 1 30-pounder rifle; |
| *T. N. Seymour* | 1 30-pounder rifle, |
| | 1 12-pounder; |
| *Ceres* | 1 30-pounder rifle, |
| | 1 32-pounder; |
| *Putnam* | 1 20-pounder rifle, |
| | 1 32-pounder; |
| *Shawsheen* | 2 20-pounder rifles; |

| | |
|---|---|
| *Granite* | 1 32-pounder. |

Army Vessels

| | |
|---|---|
| *Picket* | *Ranger* |
| *Vidette* | *Chasseur* |
| *Hussar* | *Pioneer* |
| *Lancer* | |

These vessels were armed with two or three guns each, 30-pounders and 12-pounders generally.

The troops taking part in the attack were, in round numbers, about three brigades, or twelve and a half regiments.

## Narrative of Events

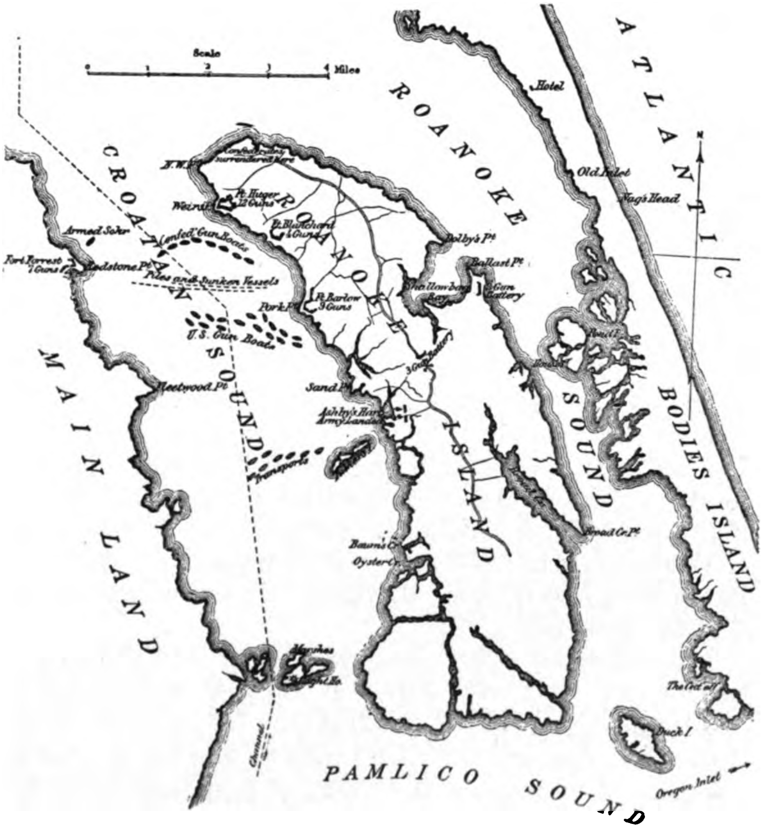
Under command of General Burnside the concentration of land troops for this movement, was begun the 23d of October, the assembly point being Annapolis, Maryland. Three brigades* were organized. They left Annapolis on the 9th of January, 1862, arrived at Fortress Monroe on January 11th, and got to Hatteras Inlet on January 13th. Some time was spent assembling the vessels there, as great difficulty was experienced in getting them over the bar. The rendezvous of the military and the naval† forces was finally completed, however, and the actual movement against Roanoke Island begun February 5th. On the 6th the fleet lay in sight of the Confederate forces.

The fleet advanced up the sound followed by the Army transports, and arrived off Fort Bartow on the morning of February 7th. The fleet was divided into two squadrons, one attacking the fort, i.e., Fort Bartow, and the other the Confederate gunboats. The navy had in action at first some seven vessels. At 10:30 a.m., on the approach of the Federal gunboats, a Confederate vessel fired one shot—evidently a signal. At 11:25 a.m. the *Underwriter* fired one shot at Sand Point, where it was thought a battery might be; but there being no reply, it was determined no fortifications were there and the fleet proceeded. Confederate gunboats were seen in rear of the barrier in Croatan Sound above Fort Bartow and shots were exchanged. The action became general by noon—the Federal gunboats engaging the enemy's vessels, the bat-

* The three brigades were commanded by Brigadier-Generals Foster, Reno, and Park, U. S. A.

† The fleet was commanded by Flag-Officer L. M. Goldsbrough, U. S. N.

teries on Pork Point (Fort Bartow), the battery north of this point (Fort Huger), and the battery across the sound (Fort Forrest). These last two batteries, however, only fired occasionally and then with little effect. During the action most of the fire was directed on the Pork Point batteries (Fort Bartow). The Confederate vessels sought to draw the Federal fire off this fort, and by retreating when pursued, tried to get




Courtesy of The Century Co. 1295

OPERATIONS AT ROANOKE ISLAND

From the Official Records

the Federal vessels entangled in the barrier and exposed to the fire of the batteries in Forts Huger and Forrest.

At 1:30 p.m. the barracks and store houses behind Pork Point were set on fire by Federal shells. At 2:15 p.m. these buildings were burning vigorously. The fort responded to the

fleet's fire steadily, but with considerable deliberation. At 2:30 p.m. the *Hetzel* was struck and hauled off.

During this bombardment the Army transports were lying off, below Ashby's Harbor, and at 3:00 p.m. they commenced landing troops at that point for a movement inland. At 4:25 p.m., the fort ceased firing. Five of the Confederate gunboats were driven back by fire of Federal vessels to Weir's Point, several being disabled. At 4:45 p.m., the Confederate troops opposing the landing of the Federal troops were dispersed by shrapnel fire from the gunboats. About 5:00 p.m., the Confederate batteries fired a few shots. It was also seen that about this time the Confederates were landing troops at Weir's Point. Firing from the batteries again commenced about 6:00 p.m., but ceased shortly. That evening naval launches with howitzers were landed and joined the Federal troops, the howitzers being the only artillery with the land troops. By midnight some 10,000 Federal troops were landed and bivouacked on the island.

Next morning, the 8th of February, at 9:00 a.m. the gunboats got under way again, and Fort Bartow resumed fire. At 9:10 a.m. the fleet was again firing into the fort, which after a time ceased to reply. At 9:35 a.m. the fleet ceased firing, so as not to hit the advancing Federal troops. The Confederates received further reinforcements, a batallion of the Wise Legion from Elizabeth City being landed at Weir's Point.

Meanwhile, the land fight was in progress, and the Confederate troops were being driven back towards the northern end of the island.

Towards noon a few shots were fired into the fort, but there was no reply—the fort was silenced and abandoned. At 4:45 p.m. it was seen by the fleet that the fort was occupied by Federal troops, and that the American flag was hoisted over the works. At 5:00 p.m. the works at Redstone Point (Fort Forrest) were abandoned and the buildings set on fire. At 7:15 p.m. it was known in the fleet that Roanoke Island had been taken, with some 30 to 40 guns and some 2000 prisoners, including the five forts.

The Confederate gunboats on the second day did not come into action, in fact were not in sight, except the *Curlew*, their largest vessel, which had been sunk near the shore.

Now looking for a moment at the bombardment from the land side and considering principally Fort Bartow, we learn

that on January 8th, 1862, the following supply of ammunition was on the island:

387 charges for 32-pounders,
1300 round shot,
250 rifle shells,

and other ordnance stores.

The ammunition available for Fort Bartow on the first day was twenty-eight rounds per gun, which during the night was again replenished to that figure, so the fort had the same amount per gun again available on the second day.

The batteries of Fort Bartow, on the first day, February 7th, opened up on the advancing fleet at 11:16 a.m. (The personnel serving the guns had arrived in the fort that morning for their regular drill, and about 10:00 a.m. discovered the enemy approaching.) The fire was at first slow, then afterwards more rapid. The gunners were inconvenienced by lack of the latest type of sight for their guns. The fort was in action firing for six hours and thirty-eight minutes, including some time after sunset.

As a result of the fleet's fire on the first day the walls of Fort Bartow were much dilapidated, but no guns were put out of action nor were there many casualties. The damage to the works was repaired by the next morning.

The second day's bombardment was of short duration—about one and a half hours in all, when fire ceased. Due to the location of the guns and the position the fleet took up, only three 32-pounder guns of the batteries were able to bear on the fleet; while the fleet fired from about sixty guns of 9-inch, 10-inch, and 11-inch calibers.

On finding that the land defenses had been forced and that the Federal troops were getting in rear of their position, the Confederates abandoned the fort, after having disabled the guns and destroyed the ammunition.

The guns at Midgett's Hommock also were spiked and abandoned.

## Ammunition Expended and Casualties

### FEDERAL

*Stars and Stripes.*—Ammunition expended,

213 8-inch shot and shell,
102 20-pounder shot,
31 Hotchkiss shell,
29 20-pounder shrapnel.

The vessel was hit once, a brace being struck. No casualties. The 8-inch guns fired on Pork Point batteries, and the 20-pounder and 12-pounder guns fired on the Confederate gunboats.

*Louisiana.*—Ammunition expended,

122 32-pounder shell,
34 8-inch shell,
25 solid shot.

The vessel was set on fire by an 80-pound projectile from one of the enemy's guns, but the fire was put out in six minutes.

*Hetzel.*—Ammunition expended,

50 9-inch shell,
22 80-pounder shot,
20 80-pounder shell.

An 80-pounder gun burst during the action, wounding its entire personnel of nine men, but no deaths resulted. The magazine was set on fire but was extinguished before serious damage was done. The vessel was struck in her coal bunkers; but the damage was repaired in half an hour. Shell from batteries exploded over the vessel, killing one man.

*Underwriter.*—Fired about twenty rounds; had no casualties.

*Delaware.*—Ammunition expended,

72 9-inch shell,
22 32-pounder,
79 12-pounder (howitzer).

*Commodore Perry.*—Ammunition expended,

172 9-inch shell,
20 9-inch shrapnel.

Range 2000 to 800 yards. Was hit seven times, five being in the hull; no material damage.

*Valley City.*—On the first day the ammunition expended was

185 32-pounder shell,
105 12-pounder shell.

Was hit once, in the foremast. No casualties. Next day expended,

3 32-pounder shot,
19 32-pounder shell.

*Barney.*—Ammunition expended,

99 9-inch shell,
25 32-pounder.

One hit in her upper works; one shell burst above the boat. No casualties. Exhausted ammunition.

*Hunchback.*—Ammunition expended,
100 100-pounder rifle shot and shell,
204 9-inch shell,
4 9-inch shrapnel.

Struck once, engine being disabled. Also struck eight other times. Opened fire at two miles range.

*Southfield.*—Ammunition expended,
6 Parrott gun solid shot,
97 Parrott gun shell,
161 11-inch shell.

One shot passed through upper works. Damage slight. No casualties.

*Morse.*—Ammunition expended,
120 9-inch shell.

Approached fort to within 1500 yards; disabled the Confederate *Curlew;* struck several times—one hit through bow; no material damage.

*Whitehead.*—Ammunition expended,
98 9-inch shell.

Range 1300 to 1500 yards. No casualties.

*Lockwood.*—Ammunition expended,
86 12-pounder rounds,
70 80-pounder rounds.

No casualties.

*Seymour.*—Ammunition expended,
91 30-pounder rounds,
112 12-pounder rifled howitzer rounds.

Had one man killed and one wounded.

*Brinker.*—No record of ammunition expended.

*Ceres.*—Ammunition expended,
88 shells (first day),
66 shells (second day).

Struck by one shot, on upper deck, deflected into fire room under boiler.

*Putnam.*—Ammunition expended,
56 20-pounder Parrott shrapnel,
47 20-pounder Parrott shells,
18 32-pounder Parrott shells,
25 solid shot.

*Shawsheen.*—Ammunition expended,
82 20-pounder shell.
No casualties.

*Granite.*—Ammunition expended,
30 32-pounder shell,
10 32-pounder shot.
No casualties.

The total casualties in the navy were:

6 killed,
17 wounded,
2 missing.

In the Federal army (all troops), the casualties were:

5 officers killed,
10 officers wounded,
32 men killed,
204 men wounded,
13 men captured or missing,

264 total.

CONFEDERATE

In Fort Bartow the casualties were:

1 killed,
3 wounded.

The ammunition expended in Fort Bartow was:

205 rounds, mostly round shot (first day),
40 rounds, mostly round shot (second day).

One gun had part of its traversing circle destroyed, allowing fire only in small arc. No guns disabled. There was on the second day the following ammunition gotten into the fort:

42 rounds for rifled gun,
155 rounds for 32-pounder smooth bore.

The Confederate boats fired very little ammunition, they being generally out of range and their small store rapidly exhausted. They withdrew on the first day, and on their return learned of the fort's surrender. They then withdrew towards Elizabeth City, where a few days later they were destroyed by Federal vessels.

It was said that Fort Bartow had fired all its ammunition, except one round; but on surrender, there were captured and found the following:

828 32-pounder round shot,
110 cartridges for 32-pounder.

In the other forts were found:

2144 32-pounder round shot,
152 32-pounder shells.

The powder in these forts, though, had been destroyed.

## Results

The result of the capture of Roanoke Island was to give the Federals control of the inland waters of North Carolina.

## Comments

1. We note a small loss of life, small damage to matériel, and a tremendous expenditure of ammunition.
2. Faulty location of batteries for control of the island.*
3. Inadequate defenses and inadequate mobile force for holding the island.†
4. An illustration of the unfortunate effect of frequent changes in command.‡
5. The loss of coast defenses through successful land attack.
6. No provision for retreat of the Confederates from the island.
7. The withdrawl of the Confederate gunboats to replenish ammunition during an action deprived the Confederates of boats, some of which might have been available for retreat.

* "The forts on the island were all out of place; they ought to have been at the south end, and they were at the north, leaving several of the landing points on the south end without any defenses against the shot and shell of the heavy steamers * * * *"— Brigadier-General Henry A. Wise, C. S. A., in letter to President Davis. (See page 112, vol. ix, Series I, Official Records of the Union and Confederate Armies.)

"† * * * The Committee have no difficulty in assigning, as the cause of our disaster and defeat on February 8, the want of the necessary defenses upon the island and the adjacent waters and upon the mainland upon the Tyrrel side; the want of the necessary field artillery, armament, and ammunition, and the great and unpardonable deficiency of men, together with the entire want of transportation, by which the whole command might have been conveyed from the island after the defeat at the battery." —Report of investigating committee of the Confederate House of Representatives. (See page 188 *ibid.*)

‡ "But the Committee have had much difficulty in locating the responsibility for the neglect of this exceedingly important point, owing to the fact that the command of that island has been transferred so frequently from one military commander to another between the time that the Confederate Government became responsible for the coast defenses of North Carolina and the attack upon the island on February 7, 1862."—*Ibid.*

8. An example of combined army and naval attack, showing coöperation.*

9. An instance of official exoneration from responsibility for defeat of the immediate commander and censure of superiors.†

## Authorities

Official Records of the Union and Confederate Armies, Series I, Vol. IX, pages 73-191.

Official Records of the Union and Confederate Navies, Series I, Vol. 6, pages 549-600.

Battles and Leaders of the Civil War, Vol. I, pages 640-647, and 660-670.

The Navy in the Civil War: The Atlantic Coast, pages 176-183.

* "In less than twenty minutes from the time the boats reached the shore 4000 of our men were passing over the marshes at a double-quick and forming in most perfect order on the dry land near the house: and I beg leave to say that I never witnessed a more beautiful sight than that presented by the approach of these vessels to the shore and the landing and forming of the troops. Each brigadier-general had a light draught steamer, to which were attached some twenty surf-boats in a long line in the rear. Both steamers and boats were densely filled with soldiers, and each boat bearing the national flag. As the steamers approached the shore at a rapid speed each surf boat was 'let go,' and with their acquired velocity and by direction of the steersman reached the shore in line."—Report of Brigadier-General A. E. Burnside, U. S. A. (See page 76, vol. ix, Series I, Official Records of the Union and Confederate Armies.)

† "The Committee, from the testimony, are therefore constrained to report, that whatever of blame and responsibility is justly attributable to any one for the defeat of our troops at Roanoke Island on February 8, 1862, should attach to Major-General B. Huger [the department commander] and the late Secretary of War, J. P. Benjamin."—Report of investigating committee of the Confederate House of Representatives. (See page 190 and 191, *ibid.*)

# A PRACTICAL METHOD FOR CORRECTING FOR PIT DISPLACEMENT IN MORTAR BATTERIES

By 1st Lieutenant JOHN H. PIRIE, Coast Artillery Corps

At target practice under the current instruction order where two companies are assigned to one mortar battery the record shots will be fired alternately from the pits and will be distributed among the mortars in each pit. It seems probable that in an action against hostile ships the same general system would be used, the pits firing alternately, but by pit salvo instead of by piece.

At a great many of our mortar batteries the centers of the two pits are fifty yards apart and the directing point used is midway between the two pits. With such a battery, if the mortars are oriented so as to be parallel when set at any given azimuth and a salvo fired from both pits, four shots should fall on one side of the target and four on the other with their centers of impact fifty yards apart. Since it has not been found practicable to use difference charts to correct for this small displacement, various methods have been used for making the correction; but most of them are too complicated for battle conditions or are only applicable to target practice conditions. There seems to be no single method in use throughout the service; so every time there is a change in battery commanders a new system is used, and if the correction is made in the plotting room the section is required to learn and drill in a new system.

The method that seems to be most generally used and seems best for range corrections, is to have lines drawn on the board at every ten or fifteen degrees in azimuth, the range corrections in yards being indicated on these lines plus or minus, as shown for "A" pit in Fig. 1.

The line C-D represents the base line and the line "A"-"B" the line joining the centers of the pits of the battery.

Suppose the azimuth of the base line to be 75° and that of the line "A"-"B" to be 125°; then, if the azimuth of the target is 125°, the range from "A" pit to the target will be 50 yards greater than from "B" pit. At an azimuth of 215° the range to the target from the two pits will be the same. If it is decided to fire the trial shots from "B" pit, the numbers representing yards correction for the displacement of "A" pit should be written on the direction lines, beginning with plus 50 at the line whose azimuth is 125° and running down to 0 at the lines whose azimuths are 215° and 35°; then with a minus sign up to 50 again at 305°.

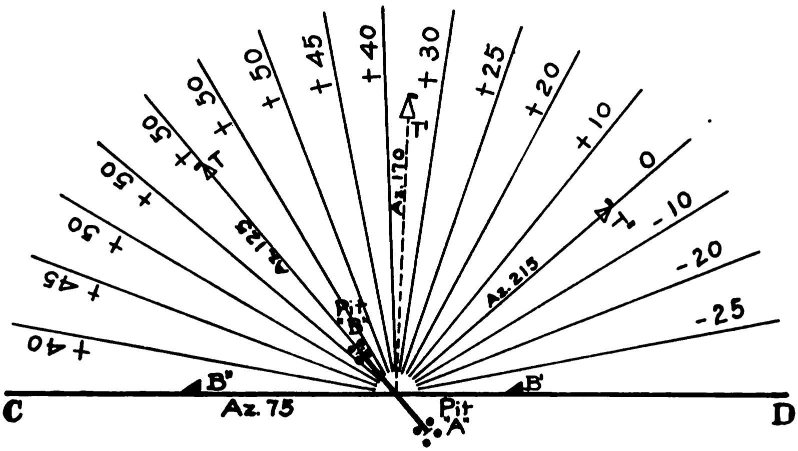



Fig. 1. 1296

After the trial shots have been fired from "B" pit and the range corrections made for the center of this pit, to apply the corrections for "A" pit during the firing at a moving target, it is only necessary for the plotter to slide the pointer on the mortar arm up or down by an amount equal to the number on the direction line nearest to the set forward point and read the elevation indicated by the pointer. If the trial shots were fired from "A" pit, the numbers on the direction lines would remain the same but all plus and minus signs would be changed.

Where the distance between pintle centers is ten yards, in correcting for the center of impact for the trial shots it should be remembered that if mortar No. 1 is used and the target is anchored in the direction of T (Fig. 1.), the range from the mortar to the splash is five yards greater than from the center of the pit to the splash. If the target is anchored

at T′, the range from the mortar is about seven yards greater than from the center of the pit.

The azimuth correction for displacement is not so easily made, since the proper correction depends upon both the range and the azimuth of the target from the battery. Such methods have been used as allowing the target to pass the wire before the signal to fire is given. This is objectionable in that, at best, it is only a guess; and, if the target is not moving exactly perpendicular to the line of fire, it is introducing an error in range that might easily be greater than the original error in azimuth. Sometimes the trial shot corrections are made for one pit and then corrections made for the other pit on the arbitrary correction scale of the deflection board. This might be well enough but for the fact that it is usually applied as a constant correction, while the proper correction varies with the range and the azimuth. (However, on the deflection board is not the easiest nor quickest place to apply the correction.) Sometimes the two pits or even all the mortars of a battery are oriented so as to concentrate at a given azimuth on some point in the center of the most important channel and at mid-range, or at the center of the expected track of the target at target practice. This is by far the worst of all the methods; for, notwithstanding the fact that it gives excellent results at target practice, it is obviously not the best for war conditions.* If, as in most of our harbors, there is a very large area to be covered by the mortars and the attack should come from some other direction than that of the point of concentration, all azimuth settings would be in error and the error would increase as the distance of the target from the concentration point increased. If the mortars were used for land defense or to cover inner waters and were fired at 180° from this point, the error would be doubled instead of corrected and the shots would fall 100 yards apart.

The following method has been tried and is entirely practicable, and has the advantage of being as applicable to battle or land defense as to target practice conditions.

First, all the mortars in the battery are oriented so as to read true azimuths, that is all to be parallel at any given azimuth setting. Then from Table I make up a table, in some convenient form such as Table II, for each zone and for all azimuths covered by the plotting board, starting with the azimuth at the extreme right or left of the board.

* It is also contrary to paragraph 529, D.R.C.A.—*The Editor*.

TABLE I

| Angle between line from Target to Directing Point and line from "A" to "B" Pit | Hundredths of degree correction for mid-range of each zone | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | ZONES | | | | | | | |
| | I | II | III | IV | V | VI | VII | VIII |
| 10 Degrees | 10 | 8 | 7 | 6 | 5 | 4 | 3 | 2 |
| 20 " | 19 | 16 | 14 | 12 | 10 | 8 | 6 | 5 |
| 30 " | 27 | 24 | 20 | 17 | 14 | 11 | 9 | 7 |
| 40 " | 36 | 31 | 26 | 22 | 18 | 14 | 11 | 9 |
| 50 " | 42 | 36 | 31 | 26 | 21 | 17 | 13 | 11 |
| 60 " | 48 | 41 | 35 | 29 | 24 | 19 | 15 | 12 |
| 70 " | 52 | 44 | 38 | 32 | 26 | 21 | 17 | 13 |
| 80 " | 54 | 46 | 39 | 33 | 27 | 22 | 17 | 13 |
| 90 " | 55 | 47 | 40 | 34 | 28 | 22 | 18 | 14 |

TABLE II

ZONE 6

| Set Dial for "A" Pit | Azimuth from Directing Point | Set Dial for "B" Pit |
|---|---|---|
| 17 | 75 | 83 |
| 14 | 85 | 86 |
| 11 | 95 | 89 |
| 8 | 105 | 92 |
| 4 | 115 | 96 |
| 0 | 125 | 0 |
| 96 | 135 | 4 |
| 92 | 145 | 8 |
| 89 | 155 | 11 |
| 86 | 165 | 14 |
| 83 | 175 | 17 |
| 81 | 185 | 19 |
| 79 | 195 | 21 |
| 78 | 205 | 22 |
| 78 | 215 | 22 |
| 78 | 225 | 22 |
| 79 | 235 | 21 |
| 81 | 245 | 19 |
| 83 | 255 | 17 |

The values in Table I are calculated for the mid-ranges of each zone and for each ten degrees of azimuth from 0° to 90° from the line joining the centers of the pits. The numbers represent the hundredths of degree to be added to or subtracted from the azimuth of the target from the directing point of the battery, in order to correct for the displacement of the center of the pit.

It is seen from Fig. 1. that if the target is at T, in prolongation of the line joining the pits, there will be no azimuth correction necessary, for the azimuth from the centers of the pits is the same as from the directing point; but if it is at T″, in a direction perpendicular to the line joining the pits, the maximum correction will be required. If the target is in the sixth zone and at an azimuth of 215° from the directing point it will be at 215°.22 from the center of "B" pit and 214°.78 from "A" pit.

A separate table similar to the one shown in Table II is made up in a convenient size for each zone and pasted on a small piece of cardboard, so that the assistant plotter will have only the one zone in use before him. The middle column contains the azimuths of the target from the directing point, and the columns headed "A" Pit and "B" Pit contain the settings of the 0 pointer of the tally sub-dial for the respective pits; that is, they represent the hundredth marks on the mortar arm azimuth sub-dial opposite which the zero of the tally sub-dial is to be set before the azimuth for "A" or "B" pit is read. The azimuth of the set forward point is then read from the tally sub-dial instead of from the mortar arm azimuth sub-dial and is the azimuth of the set forward point from the center of "A" or "B" pit. In making the correction by this method it is only necessary for the assistant plotter to keep before him the table for the proper zone and be told which pit is to fire. He then looks on his table for the setting of the tally sub-dial opposite the azimuth of the target and sets the zero of the dial opposite the number given in the column headed "A" or "B" pit. Then when the arm is brought to the set forward point he reads the azimuth from the azimuth circle and tally sub-dial.

When the arm is brought to the predicted point the azimuth is read from the azimuth sub-dial for the B. C. instrument.

These corrections could of course be made on the arbitrary correction scale of the deflection board, but it can be

much more easily and quickly made on the tally sub-dial. It is possible by this method to supply corrected data to both pits, by shifting the dial from the setting for one pit to the other and getting two azimuth readings; but each azimuth must be corrected on the deflection board, and without separate lines to the pits much time is lost in the transmission of the data.

In making up the tables, care must be exercised to be sure that the correction is made in the proper direction. It is only necessary to remember that when the azimuth is to be increased the tally sub-dial must be rotated in a counter-clockwise direction. It will be noted that as the line on the board that is in continuation of the line joining the pits is passed by the target, the settings of the dial for both pits pass through zero and are then in the opposite direction on the other side of this line.

The only objectionable feature of the system seems to be that an inexperienced assistant plotter may read the wrong degree under certain conditions. For instance, if the azimuth of the target is 163°.11 from the directing point and "A" pit is to fire, and if from Table II the setting is 14, the pointer would be opposite .97 on the tally sub-dial and the correct reading for "A" pit would be 162°.97. This might be read 163°.97 due to the fact that the azimuth pointer on the degree scale has passed the 163° mark. It has been found however that mistakes like this hardly ever occur after an assistant plotter has drilled with the system for three or four times.

With the 360-degree mortar-plotting-board there would be a set of tables made up for each base line; or let the one set of tables extend around the whole 360 degrees. The corrections would be made by setting the arrow on the drift slide opposite the proper reading on the deflection scale. The tables would be made up with 3 as the normal instead of 0 or 100.

Another method for using the tables described above is as follows. Make up for each pit a device similar to the azimuth sub-dial and pointer and the tally sub-dial as shown in Fig. 2. This can be made of cardboard and arranged so that the inner circle (a) and the pointer (b) turn about a pin at the center of the outer circle (c). Each circle is divided into 100 equal parts and numbered as on the sub-dials on the plotting board.

In a battery where the data is transmitted by telephone from the plotting room to a booth and then posted, there should be an extra man stationed in each booth to operate this device.

He should keep the zero of the inner circle set opposite the hundredth mark on the outer circle corresponding to the "setting" opposite the azimuth of the target and in the column for his pit. When the azimuth is received from the plotting room he sets the pointer opposite the hundredth mark on the inner circle corresponding to the hundredths of degree in the azimuth received and reads the corrected hundredths from the outer circle. This corrected azimuth is then posted for the laying of the mortars of the pit.

After a few drills the pointer is no longer needed and the operator has no trouble in making the proper correction when a change in the last degree of the azimuth is necessary.

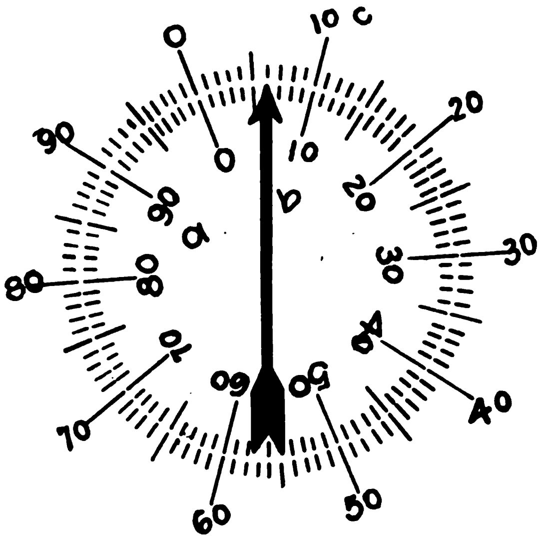


FIG. 2. 1297

Since the inner circle is turned instead of the outer one, as in the case of the tally sub-dial, the "settings" given in Table II are reversed and the column headed "A" Pit would be headed "B" Pit.

If mechanical transmission of firing data is used, there would have to be separate wires installed for each pit, and the man operating this device would have to be stationed in the plotting room.

This method of using the tables has the advantage of being as easily applied to the use of the 360-degree plotting board as to the old board, and the correction for both pits can be as quickly made as for one.

# REPORT ON COMBINED EXERCISES IN THE ARTILLERY DISTRICT OF THE POTOMAC, OCTOBER 1st TO 16th 1912

By Captain WILLIAM H. WALDRON, 29th Infantry

## OUTLINE OF SCHEME OF INSTRUCTION

It was the endeavor to make the course of instruction of an elementary character, covering as thoroughly as practicable, in the limited time available, the duties that would devolve upon company officers and non-commissioned officers, when called into active service in time of war.

With this object in view the time was divided into two periods:

I. The Instructional Period, during which time the theoretical instruction of officers and non-commissioned officers was paramount.

II. The Practical Period, during which time the officers and non-commissioned officers should have the opportunity of applying, with troops, the principles learned during the Instructional Period.

The following general plan was adopted and carried out:

1. A course of lectures (three in number) covering the service of security and information—patrols, outposts, advance, flank and rear guard. Attended by all officers and non-commissioned officers.

2. Tactical walks for officers on the afternoon of the day following the lecture—for example, lecture to-night, on the conduct of infantry patrols, tactical walk on the subject to-morrow afternoon.

3. On the forenoon following the tactical walk for officers, company commanders required to conduct a tactical walk in the subject, for the non-commissioned officers of their companies.

4. In order that other members of the command should not remain idle during the preliminary instruction of the officers and non-commissioned officers, the companies to be

given such exercises and instruction as is practicable, to prepare them for the camp and exercises of the week to follow.

5. It was thought that the above course of instruction could be carried out to best advantage with the troops in their permanent barracks where the officers and non-commissioned officers would not have their time taken up and their attention diverted from this important work by the extra duties that would devolve upon them in camp.

6. For the practical period the entire command to be required to go into camp. In order to get the troops entirely out of touch with their permanent barracks, the camp to be established across the river from Fort Washington, on the Fort Hunt reservation.

7. The practical exercises to be progressive in character involving:

(a) The service of security and information.

(b) A short march, security and information, establishment of bivouac, individual cooking, followed the next day by a short march and a combat exercise involving the attack and defense of a position (meeting engagement).

(c) The principles of combat, attack and defense of a position,

(1) Covering removal of supplies that had been collected,

(2) Covering a landing for a larger force.

(d) The principles of combat, volume of fire controlled by umpire by means of flags.

The preliminary course of instruction was published in General Orders No. 7, Headquarters Artillery District of the Potomac as follows:

Headquarters Artillery District of the Potomac

General Orders, No. 7. } Fort Washington, Maryland, October 2, 1912

The following schedule for the combined exercises under paragraph 146, Practice Regulations, 1912, are published for the information and guidance of the troops of this command:

WEDNESDAY, 2ND OCTOBER

8:00 p.m. *Lecture.* Infantry patrols, by Captain Waldron. Post Exchange building. All officers and non-commissioned officers.

THURSDAY, 3RD OCTOBER

8:00 a.m. to 9:30 a.m. *Extended Order Drill.* Infantry Drill Regulations, Pars. 199 to 224, inclusive.

| | |
|---|---|
| 10:00 a.m. to ——— | *Tent Pitching.* I. D. R., pars. 799 to 803, inclusive. Each company will pitch a camp with the class of tents with which it is equipped. |
| 10:00 a.m. to 11:45 a.m. | *Signalling.* Signal squads of four men from each company will report to the Post Artillery Engineer at 10:00 a.m., for instructions. |
| 1:30 p.m. | *Tactical Walk.* Officers—Infantry patrols. |
| 8:00 p.m. | *Lecture.* Infantry outposts by Captain Waldron. Post Exchange building. All officers and non-commissioned officers. |

FRIDAY, 4TH OCTOBER

| | |
|---|---|
| 8:00 a.m. to 9:00 a.m. | *Shelter Tent Pitching.* This instruction will be conducted by company for the first half hour, at the end of which time the companies at Fort Washington will be organized into a provisional battalion under the senior officer present and a battalion shelter tent bivouac will be made. |
| 9:30 a.m. | *Kitchen Incinerator.* Each company will construct a company kitchen incinerator, complete, under the immediate supervision of the company quartermaster sergeant. |
| 9:30 a.m. | *Tactical Walk* for the non-commissioned officers conducted by company officers. Subject—Infantry patrols. |
| 1:30 p.m. | *Tactical Walk.* Officers—Infantry outposts. |
| 8:00 p.m. | *Lecture.* Infantry advance guards by Captain Waldron. Post Exchange building. All officers and non-commissioned officers. |

SATURDAY, 5TH OCTOBEK

| | |
|---|---|
| 8:00 a.m. to 9:30 a.m. | *Instruction* in the construction of infantry trenches. Each company will dig at least 25 feet of the fire trench shown in Fig. 1, page 133, I. D. R., see par. 590, I. D. R. Location of trenches at Fort Washington will be designated by Captain Matson. |
| 10:00 a.m. to noon. | *Tactical Walk* for non-commissioned officers. Conducted by company officers. Subject: Infantry outposts. |
| 1:30 p.m. | *Tactical Walk.* Officers—Infantry advance guards. |

SUNDAY, 6TH OCTOBER

| | |
|---|---|
| 9:30 a.m. | *Lecture* by 1st Lieut. W. B. Carr, M. C.<br>Subject: (a) Camp sanitation.<br>(b) First aid to injured (illustrated). |

MONDAY, 7TH OCTOBER

The command will go into permanent camp at Fort Hunt, Va. Details will be published later.

NOTES:—For the afternoon tactical walks officers will report at Post Headquarters at the designated hour. Equipment: field glass, compass, watch, note book, and pencil.

By Order of Colonel Allen:

(sgd.) G. L. Van Deusen,
2nd Lieutenant, Coast Artillery Corps,
Adjutant.

This schedule of instruction was carried out in all its details.

## NOTES ON CONDUCT OF INSTRUCTIONAL PERIOD

The signalling prescribed for 10:00 a.m., 3rd Oct. was conducted as follows: Three signal stations were established at Fort Washington and three at Fort Hunt. Messages were furnished the squads by the umpire for transmission. The exercise was efficiently conducted.

The tactical walk for officers (1:30 to 5:00 p.m.) in the conduct of Infantry Patrols was conducted in the vicinity of Fort Hunt. The several situations were given out as the points along the route were reached. Every point was thoroughly explained and each officer required to submit a memorandum on the spot, covering his solution. The problem proposed for solution was as follows:

### TACTICAL WALK: INFANTRY PATROLS

Maps: Fort Hunt and Vicinity.
Patuxent and Mt. Vernon Sheets, G. S.

*General Situation:* The Potomac River forms the boundary between hostile States. A Blue force occupies PISCATAWAY. A Red force is reported in the vicinity of ALEXANDRIA.

*Special Situation. Blue:* A Blue detachment consisting of one battalion of infantry crossed the POTOMAC today and is bivouacked for the night near FORT HUNT with an outpost line extending along the northwestern boundary of the reservation.

Support No 2 is located at this point. (West exit of reservation.)

### Situation No. 1

You, Lieutenant A, have been detailed for patrol duty and receive the following instructions from the support commander:

"A force of the enemy is reported in the vicinity of ALEXANDRIA. Contact has not yet been gained. Our patrols are reconnoitering north along the POTOMAC RIVER, and west along LITTLE HUNTING CREEK.

"You will take this patrol of one non-commissioned officer and five men and reconnoiter along the NECK ROAD in the direction of ALEXANDRIA. Locate the enemy, ascertain his strength and composition.

"Return when darkness prevents further reconnaissance.

"Send messages to this point."

REQUIRED: What are your duties before starting out with your patrol?

Situation No. 2

Your patrol has advanced thus far. You, yourself, are at this point. (Point 1 on Map.)*

REQUIRED: What is the disposition of your patrol?

Situation No. 3

At this point (just north of Point 2 on Map) you meet a countryman coming from the direction of ALEXANDRIA.

REQUIRED: (a) What questions would you ask the countryman?

(b) What disposition would you make of him?

Situation No. 4

The countryman informs you that he was in ALEXANDRIA at 9:30 this morning. He saw some infantry and artillery. Number indeterminate. They were preparing to march. He heard of no other troops closer than MANASSAS. He is on his way to MT. VERNON. The roads to ALEXANDRIA are in fine condition.

REQUIRED: Write out the message that you would send back to the support commander.

Situation No. 5

On arriving at this point (on Neck road northwest of Grassymede) your leading scout signals "enemy in sight," and on examining you observe a party of the enemy which you estimate to be eight men, advancing south along the NECK ROAD. (Location to be pointed out.)

REQUIRED: What action do you take?

Situation No. 6

On arriving at this point you observe a force of the enemy going into bivouac in that field (pointed out, head of Little Hunting Creek). There are apparently 14 lines of shelter tents. One short and one long picket line are being established.

REQUIRED: (a) What action do you take?

* Maps are omitted.

(b) What disposition do you make of your patrol?
(c) To be given verbally. (Write out the message that you would send back to the support commander.)

Situation No. 7

The enemy's patrols are becoming very active in your vicinity. The patrol just observed has passed and moved on towards FORT HUNT.

REQUIRED: What action dc you take?

This problem was designed to illustrate the operations of an infantry patrol (reconnoitering) sent out from an outpost line.

Situation No. 1 illustrates the order that should be given the patrol commander. The requirement involves:

a. The inspection of the patrol by the commander, including ammunition, arms, accoutrements, equipment, and physical condition of the men.

b. The instructions given by the patrol commander to the members of his patrol, including: information of the enemy and friendly patrols sent out, mission of the patrol, such detailed instructions and plans as may be necessary, designation of an assembly point for men that may become detached, signals, where messages will be sent.

Situation No. 2 was designed for the purpose of bringing out the detailed formation of the patrol at a given point. Officers were required to draw a rough sketch showing the exact location of each member of the patrol. When completed these sketches were submitted to the umpire for examination. The formation was then taken up in detail and reasons explained for the position and conduct of each man of the patrol.

Situation No. 3 was designed to illustrate the process of questioning civilian natives of the country in which the patrol is operating. Each officer was required to write out the questions he would ask in this instance. Requirement (b) was solved verbally.

Situation No. 4 was designed to promote proficiency in the writing of field messages. This message was written out on message blanks, and submitted to the umpire by each officer. The messages were then discussed and errors pointed out. Afterwards a "satisfactory message" was composed and submitted for discussion.

Situation No. 5 was designed to illustrate the action of the patrol when coming into contact with the enemy. This solution involved:

a. The disposition to be made of the several members of the patrol.

b. The action to be taken by the patrol commander with respect to the enemy.

c. The question of sending back a message.

All of these points were thoroughly discussed and a "satisfactory solution" arrived at.

Situation No. 6 was designed to illustrate:

a. The disposition of the members of the patrol when a considerable body of the enemy is sighted.

b. The method of computing the enemy's strength and composition.

c. The framing up of the message that the patrol leader would send back to his support commander.

d. The method of sending this message back in view of the close proximity of the enemy's patrol.

Situation No. 7 was designed to illustrate the conduct of a patrol: after it had accomplished its mission and its position was rapidly becoming more dangerous due to the activities of the enemy.

A "satisfactory solution" was arrived at and thoroughly discussed on the ground.

The work of constructing company kitchen incinerators was most instructive. Some of the companies constructed more than one type. Several types were developed, among them the small circular incinerator with a cone of rocks in the center, the simple trench type, the rectangular deep pit type, the radiating trench type with chimney, and one above ground built with brick.

The tactical walk for non-commissioned officers was conducted by the company officers, who each prepared a simple problem with several situations for solution.

The tactical walk for officers (1:30 to 5:30 p.m.) 4th October, in the formation and posting of an infantry outpost was conducted in the vicinity of Fort Washington. The situation was given out near the point where No. 2 support of the outpost line was to be posted. The problem proposed for solution was as follows:—

## Tactical Walk: Infantry Outposts

Maps: Fort Washington and Vicinity.
Patuxent Quadrangle, G. S.

*General Situation:* The Potomac river forms the boundary between hostile States. A Red force is at MT. VERNON. A Blue force has been reported in the vicinity of CAMP SPRINGS.

*Special Situation, Red:* A Red detachment consisting of one battalion of infantry with orders to reconnoiter in the direction of the lower PATUXENT RIVER has arrived at FORT WASHINGTON. Major A, commanding, decides to bivouac just east of FORT WASHINGTON, and issues the following orders.

"Information has been received that there is a force of the enemy in the vicinity of CAMP SPRINGS. Our main forces remain at MT. VERNON.

"This battalion will bivouac on the high ground about ¼ mile east of FORT WASHINGTON and south of the FORT WASHINGTON—PISCATAWAY ROAD.

"Captain B, with Company B, will form the outpost covering the roads to the north and east.

"The remaining companies will bivouac in column of companies, tents facing east, officers tents on right flank. A detached post will be posted from the main body, south of camp. In case of attack the outpost will be supported. The outpost line will be intrenched to such extent as may be practicable.

"Field wagons will join their companies."

"Messages will be sent to the bivouac of the main body."

### Situation No. 1

You, Captain B, are in command of company B, the organization designated for outpost duty. You have arrived at this point, having marched with one squad 200 yards in advance.

REQUIRED: Write a memorandum showing the elements that would be included in your verbal order to your company for establishing the outpost.

NOTE: It is assumed that you have a company of 12 squads. The two lieutenants are present.

### Situation No. 2

You, Lieutenant A, with six squads, are detailed to post support No. 2.

REQUIRED: (a) Memorandum showing the disposition of the several elements of your support, and arrangements for security.
(b) The verbal orders that you would give to patrols sent out.
(c) Where would you dig fire trenches?

Situation No. 3

You, Sergeant X, with two squads are detailed to post and command outguard No. 2 of support No. 2.

REQUIRED: (a) A memorandum showing the disposition of the several elements of your outguard. Arrangements for security.
(b) The verbal instructions that you would give the left sentinel of the outguard.

Situation No. 4

You, Lieutenant A, have completed the posting of your support, verified and rearranged all the elements and sent out the necessary patrols.

REQUIRED: Write out the report that you would make as support commander to the outpost commander. Accompany same by a rough sketch showing dispositions.

This problem was designed to illustrate the halt order that would be issued by the commander of a small force, including the provisions for security (outposts).

Situation No. 1 involves the duties that will fall upon the company commander in the establishment of the outpost. The officers taking the walk were requested to consider themselves in the position of the company commander with their company formed up in column of squads on the road, with a small covering detachment sent out a short distance in the direction of the enemy. What verbal orders would be given for forming the outpost? Each officer was required to submit a memorandum showing the elements that he would include in such an order. These memorandums were turned in and after a thorough discussion of same, a "satisfactory solution" was arrived at. This solution was gone over and indelibly impressed on every member of the class. The importance of adhering closely to the form of order prescribed in F. S. R., was impressed upon all, as being applicable in its essential details to an outpost consisting of one company as well as that

of a brigade, and that if the sequence prescribed is followed on all occasions there is little danger of omitting one or more of the essential details of an order.

After having solved the first situation the second was given out and the officers allowed 40 minutes to examine the ground with a view to posting the support. These solutions were discussed on the ground and a satisfactory solution arrived at. The class was then conducted over the right sector of the line of observation covered by support No. 2. The position of the outguard was pointed out. The location of fire trenches was indicated on the ground and the reasons for so locating them explained.

The class then proceeded to the location of outguard No. 2, and all the details of posting same and locating sentinels and instructing them was thoroughly discussed on the ground.

It was so late when all of this work was completed that the officers were not required to make a sketch of the position, as it would have been considerably after dark before it could have been completed. The necessity for and method of making the sketch were explained.

The tactical walk for officers (1:30 to 5:30 p.m.) 5th October, in Infantry Advance Guards, was conducted in the vicinity of Fort Washington. The problem proposed for solution was as follows:

### TACTICAL WALK: INFANTRY ADVANCE GUARDS

Maps: Road Map—Fort Washington and Vicinity.

*General Situation:* The Potomac river forms the boundary between hostile States. A Red force is at MT. VERNON, FORT HUNT will be occupied today. A Blue force has been reported in the vicinity of CAMP SPRINGS.

*Special Situation, Red:* A Red detachment consisting of one battalion of infantry on reconnaissance crossed the river yesterday and bivouacked last night ¼ mile east of FORT WASHINGTON with outposts covering the roads to the north and east along the line KUBA—CHANDLER—HOMION.

Major A, commanding, decides to continue the march, and at 1:30 p.m. issues the following verbal orders:

"A force of the enemy is reported in the vicinity of CAMP SPRINGS. Contact has not yet been gained. Our main forces remain at MT. VERNON. FORT HUNT will be occupied today.

"This detachment will march towards FRIENDLY.

"Captain C, with Company C, will form the advance guard marching by the PATE-KING-SHORTER-SHERES-THOMAS-ROLAND road. The advance party will clear the road fork just west of HUSHART at 2:00 p.m.

"The main body in order of march, Companies A, D, B, will follow the advance guard at a distance of 400 yards.

"The outpost will stand relieved when the point of the advance guard crosses the line of observation and take its place at the rear of the column.

"The field trains will follow the main body without distance.

"Messages will reach me at the head of the main body."

Situation No. 1

You, Captain C, are in command of Company C, the organization detailed for advance guard duty.

REQUIRED: The verbal order that you would issue to your company.

Situation No. 2

You, Lieutenant K, are detailed to command the Advance Party, consisting of the 1st platoon, six squads.

REQUIRED: The dispositions you would make and the instructions you would issue to your platoon.

Situation No. 3

The advance party of your advance guard has arrived at this point.

REQUIRED: What is the disposition of the several elements of your advance guard?

Situation No. 4

When the head of your advance party arrives at this point you receive a message from Major A that the main body will halt for an hour.

REQUIRED: The measures taken by the advance guard for the protection of the main body during this halt.

Situation No. 5

The command has been halted for 30 minutes. You hear firing which seems to be in the direction of the THOMAS HOUSE.

At this time you receive a message from your patrol commander dated 15 minutes earlier from BORDIN HOUSE, the body of which is as follows:

"Inhabitant reports that he saw the enemy south of CAMP SPRINGS before noon, marching south on the CAMP SPRINGS-FRIENDLY road. Estimate to be one infantry battalion. Am retaining inhabitant as a guide. Will continue reconnaissance towards FRIENDLY.

REQUIRED: (a) What action do you take?
(b) Write out the message that you would send back.

This problem was devised for the purpose of instructing the officers in the duties that will devolve upon them when called upon to conduct an infantry advance guard.

1. The order for the march and the designation of the advance guard.

2. The verbal orders necessary to be issued by the advance guard commander.

3. The dispositions of and the instructions to be issued to the advance party.

4. The actual disposition of the advance guard at a given point on the line of march.

5. The measures taken by the advance guard commander for the security of the main body, when the latter is compelled to halt for a considerable period of time.

6. The action of the advance guard when contact is gained and the messages sent back.

The class was conducted to the initial point, where the exercise was started. The problem was read and explained. Attention was called to the form of the order for the march and stress laid upon adhering to the form as laid down in Field Service Regulations. The officers were required to write out in memorandum form the order that they would give, verbally, to their company, under the conditions of the problem. After the solutions were all submitted and discussed, a "satisfactory solution" was arrived at. Officers were then requested to assume that their company was formed up before them and waiting for orders. Certain members of the class were required to give the various paragraphs of the order until all were familiar with the procedure to be employed in issuing such an order.

The class then passed on to the solution of situation No. 2, which was worked out in all its details, thoroughly discussed and any point not understood carefully explained.

The class then proceeded to a designated place on the road where members were required to give, verbally, the location of each element of the advance guard and explain the tactical reasons for such dispositions.

Situation No. 4 was given out at a road fork (just south of Sherfs) where the terrain was admirably suited for working out the details of the disposition of an advance guard to cover the halt of the main body. The members of the class made rough sketches or memorandums showing their several solutions. These were discussed and a "satisfactory solution" arrived at.

The problem involved in situation No. 5 was supposed to have taken place when the column had been halted for 30 minutes, and involved the action of the advance guard commander when the enemy is encountered by advance detachments under such circumstances.

This was a most instructive phase of the problem and brought out many points for discussion and solution. Officers were required to indicate on the ground the action taken and give their reasons therefor. Stress was laid on the development of the enemy, and the principle of bringing on an action that may be at variance with the wishes of the commander of the whole force, etc.

As a whole, the problem brought out many points for discussion and it is believed that all the officers had a much clearer idea of the importance of and the difficulties encountered by an Infantry Advance Guard.

On Sunday morning, 6th October, 1st Lieutenant W. B. Carr, Medical Corps, gave a lecture as indicated in the schedule, to the assembled officers and men at Fort Washington, and repeated the same at Fort Hunt later.

It was intended to place the command in camp at Fort Hunt, Monday, 7th October; but practically all the troops from Fort Washington were ordered to the city of Washington for duty as escort, which prevented their going into camp until Tuesday, 8th October.

## NOTES ON CONDUCT OF THE PRACTICAL PERIOD

The troops included in the Artillery District of the Potomac went into camp at Fort Hunt, Va., Tuesday, 8th Oct., 1913.

The orders and instructions indicated below were issued, establishing the camp and providing regulations for the conduct of the second period of instruction:

1. General Orders No. 8,* Artillery District of the Potomac, arranging for the preliminary details of the encampment. (NOTE:—It was originally intended to establish the camp Monday, 7th October, but the troops were ordered to Washington city for escort duty, and the date had to be postponed.)

2. General Orders No. 1, Camp Wallace F. Randolph, establishes the camp, details the staff, publishes the list of service calls, the schedule of instruction and other essential details.

3. General Orders No. 2,* Camp Wallace F. Randolph, publishes the orders and instructions for the guard.

4. General Orders No. 3,* Camp Wallace F. Randolph, publishes the sanitary regulations for the encampment.

5. Memorandum,* publishes the regulations for the guidance of the troops in the conduct of field exercises.

Headquarters Camp Wallace F. Randolph

GENERAL ORDERS, No. 1. } Fort Hunt, Virginia, October 8, 1912

I. The undersigned hereby assumes command of this camp.

II. The camp will be officially known as "Camp Wallace F. Randolph."

III. The following Staff is announced:—

2nd Lieut. George L. Van Deusen, C. A. C., Adjutant and Acting Quartermaster and Commissary.

Capt. William H. Waldron, 29th Inf., Instructor and Umpire.

Capt. Joseph Matson, C. A. C., Umpire.

1st. Lieut. William B. Carr, Medical Corps, Camp Surgeon.

IV. The following hours of service and roll calls are announced:—

| | | |
|---|---|---|
| Reveille | | |
| First Call | 5:30 | A. M. |
| Reveille | 5:40 | " " |
| Assembly | 5:45 | " " |
| Mess (Breakfast) | 6:00 | " " |
| Sick | 6:30 | " " |
| Fatigue (Police) | 6:40 | " " |
| Mess (Dinner) | 12:00 | Noon. |
| 1st Sergeants | 4:15 | P. M. |
| Guard Mounting | 4:30 | " " |
| Assembly | 4:40 | " " |
| Mess (Supper) | 5:00 | " " |
| Retreat | | |
| First Call | 5:20 | " " |
| Assembly | 5:30 | " " |

* Not published herewith.

| | |
|---|---|
| Retreat | 5:35 P. M. |
| Tattoo | 9:00 " " |
| Taps | 10:00 " " |

Formations at reveille and retreat will be under arms.

The time kept at these headquarters will be the official time of the camp.

Each company will be inspected by one of its officers before being dismissed after retreat.

## V. PROGRAM OF INSTRUCTION

| | |
|---|---|
| Tuesday, 8 October | Troops prepare camp at Fort Hunt, Virginia. |
| Thursday, 10 October | Exercise. Outposts and patrolling. Hostile contact. |
| Friday, 11 October | Exercise. Short march under service conditions. Advance—flank and rear guards—followed by bivouac over night. Individual cooking. Three meals to be prepared. |
| Saturday, 12 October | Exercise. March under service conditions. Meeting engagement. |
| Sunday, 13 October | Inspection of troops and camp by Camp Commander, 9 a.m. |
| Monday, 14 October | A.M.: Pay day for troops. P.M.: Exercise. Attack and defense of position. |
| Tuesday, 15 October | Exercise. Defense of position. Covering small landing force. Attack of same by a superior force. |
| Wednesday, 16 October | A.M.: Controlled attack of defensive position by three company war strength battalion. Flag control by umpire. Par. 357—Infantry Drill Regulations. P.M.: Troops break camp and return to proper stations. |

Unless otherwise notified troops will hold themselves in readiness at 7:30 a.m., daily for exercise or maneuvers.

## VI. INSPECTION FOR BALL CARTRIDGES

Organization Commanders will inspect thoroughly for *ball cartridges* at each formation for exercises under arms. Report of result of each inspection will be made at once to the Adjutant. In case any ball cartridges are found, special report in writing will also be submitted.

VII. Between reveille and tattoo enlisted men not specially restricted may visit within the limits of Fort Hunt reservation without pass.

Passes to leave the reservation will state the purpose of same and be submitted to the Camp Commander for approval.

Enlisted men will not leave the body of encampment between tattoo and reveille without approved pass. Departure and return on approved passes will be made at the guard tent. All enlisted men reporting departure will be neatly dressed in prescribed uniform.

VI II.Private houses, enclosures, orchards, haystacks, schools, churches, etc., will be scrupulously respected. Enlisted men are forbidden to enter private premises without special permission of the owner.

All officers and non-commissioned officers are made responsible for the enforcement of this order and will promptly arrest and report all offenders.

IX. Visitors will be allowed in camp:—

(1) By special permission of Commanding Officer.

(2) At headquarters and company officers' tents, when visiting officers, between 4 p.m. and tattoo.

(3) In company officers' street and company streets from retreat until 7:30 p.m.

(4) No visitors will be allowed to enter camp, except when escorted by an officer, during the absence of troops at exercises.

(Sgd.) S. E. Allen,
Colonel, Coast Artillery Corps,
Commanding.

The troops moved by company from Fort Washington camp, and by 4:00 p.m. were all comfortably encamped at Camp Wallace F. Randolph.

The following consolidated report shows the average number of officers and enlisted men present during the encampment:

| Organizations | Officers | Enlisted Men |
|---|---|---|
| Field and Staff | 4 | |
| Medical (Sanitary) | 1 | 3 |
| 17th Company, C. A. C. | 1 | 80 |
| 44th Company, C. A. C. | 1 | 79 |
| 47th Company, C. A. C. | 2 | 90 |
| 104th Company, C. A. C. | 1 | 78 |
| 119th Company, C. A. C. | 2 | 72 |
| 143rd Company, C. A. C. | 1 | 81 |
| Total | 13 | 483 |

Each company was provided with one escort wagon and two draft mules. One ambulance with two mules was assigned for duty.

Temporary kitchen shelters were provided. Kitchen incinerators of the open trench type lined with rock were constructed. The latrines were of the modified Havard type, fly proof, dark interior. Temporary pipe lines were laid and the water system of Fort Hunt tapped. Each company was provided with one hydrant. Water of sufficient quantity and excellent quality.

In view of the fact that the troops of this command will be required to march to and from Edsall, Virginia, for their annual small arms target practice, it was thought that such

marches would answer for practice marches, and that the limited time available could best be devoted to maneuver exercises. Therefore, no extended practice march was included in the program of field instruction.

Provisional battalions were organized from time to time as required. This method proved most satisfactory in that the offensive and defensive rôle of the troops could be varied so as to give them experience in both.

The following pages of this report show the tactical problems proposed for solution and a synopsis of daily events:

* * * * * *

THURSDAY, 10TH OCTOBER

Problem No. 1. Outposts and Patrolling.

Map: Fort Hunt and Vicinity. Country just west of Fort Hunt.

This problem was designed to illustrate:—

1. The posting of a small outpost consisting of a provisional battalion of two companies of infantry and the performance of outpost duty when in close contact with the enemy.

2. The development of an outpost line by reconnaissance, with a view to securing information on which a superior commander may base his plans for an attack of same.

3. The difficulties encountered by the outpost troops to prevent the main line being developed by an inferior force of the enemy, and the difficulties encountered by such a force in the development of an outpost line held by a superior force.

The following is the problem proposed for solution:

*General Situation:* The Potomac river forms the boundary between hostile States. A Blue force is in the vicinity of FRIENDLY. A Red force is at ACCOTINK. Contact has not yet been gained.

*Special Situation, Blue:* A Blue detachment consisting of two battalions, after a night march, crossed the river this morning to FORT HUNT. There will be several hours delay in ferrying transportation and supplies. Colonel A, commanding, decides to halt at FORT HUNT until late this afternoon, and issues the following verbal order:

"The enemy is reported in the vicinity of ACCOTINK. Contact has not yet been gained. Our main forces remain at FRIENDLY. There will be several hours delay in ferrying our transportation and supplies.

"This detachment will bivouac at FORT HUNT until further orders.

"Captain Wilson (Ralston) with the 143rd and 44th (17th and 104th)* Companies will establish the outpost along the line 1—8—7, covering the roads to the west and northwest. Patrols will be pushed out towards LITTLE HUNTING CREEK.

"The remainder of the detachment will bivouac at FORT HUNT. In case of attack the outpost will be supported.

"The field wagons will park on the parade.

"Messages will reach me at the bivouac of the main body."

You, Captain Wilson (Ralston) are in command of the 143rd and 44th (17th and 104th)* Companies, detailed for outpost duty.

REQUIRED: Carry out your orders.

NOTES: a. Members of the command participating in the exercise are positively prohibited from obtaining information from inhabitants of the country.

b. The old observation tower will not be used by the outpost.

*Special Situation, Red:* A Red detachment consisting of one battalion marched last night from ACCOTINK to MT. VERNON, where it halted.

You, Lieut. Cunningham, (Captain McMillan) with the 119th (47th)* Company have marched out on a reconnaissance.

On arriving at this point you receive a message from your battalion commander, the body of which reads as follows:

"A force of the enemy, two battalions, crossed the POTOMAC this morning from FORT WASHINGTON. A reliable inhabitant informs me that the enemy's water transportation has been disabled and he will be delayed in getting supplies across the river. This may force him to remain in the vicinity of FORT HUNT for the day. A strong detachment of our forces is now marching from ACCOTINK to MT. VERNON with a view to defeating the enemy before he can receive reinforcements.

"You will reconnoiter in the direction of FORT HUNT. Locate the enemy's outpost line, ascertain its strength and dispositions.

"Send messages to me at MT. VERNON."

REQUIRED: Carry out your orders.

NOTES: a. The company commander will write out on message blanks, the messages that he would send back to MT.

* The commander and the companies indicated in parentheses are for the afternoon exercise, those not in parentheses being for the morning exercise.

VERNON, and turn them in to the umpire at the conclusion of the maneuver.

b. Members of the command are positively prohibited from securing information from the inhabitants of the country.

At 7:30 p.m., a conference on both the forenoon and afternoon exercises was held. Officers and non-commissioned officers attended. A large scale map was prepared for the occasion. The solutions as executed were explained in detail by the several commanders after which a solution was submitted by the umpire for discussion. Tactical errors in the execution of the exercise were pointed out and corrections proposed and explained in detail.

FRIDAY AND SATURDAY, 11TH AND 12TH OCTOBER

Problem No. 2. Short marches under service conditions. Advance, flank and rear guards. Followed by bivouac over night (11-12 Oct.). Individual cooking. March. Meeting engagement.

Map: Fort Hunt and Vicinity.

This problem was prepared to illustrate the following principles:

*The Red Situation:*

1. The withdrawal of an advance detachment which has completed its mission, to a place of safety.

2. The method of conducting a flank march, (from 25 to 24) which changes into a retirement at 24.

3. The making of a bivouac for the night. The establishment of an outpost covering same and maintaining contact with the enemy by means of patrols.

4. The process of individual cooking in the field. Each man was required to cook three meals. (Dinner and supper of the 11 October and breakfast 12 October.) The components of the haversack ration were issued for the occasion. Men were not permitted to supplement this ration with other food.

5. The march of a command acting as a flanking detachment for a larger force.

6. A meeting engagement. Orders being to drive back any small parties of the enemy.

*The Blue Situation:*

1. The withdrawal of a small detachment to a place of safety, before the threatened advance of a superior force of the enemy.

2. The method of conducting a retirement. Protection of train. Rear guard duty.

3. The making of a bivouac for the night. Establishment of an outpost covering same and maintaining contact with the enemy by means of patrols.

4. The process of individual cooking as explained in the Red Situation, Par. 4.

5. The march of a command acting as a flanking detachment for a larger force.

6. A meeting engagement of two forces. Orders being to oppose the advance of the enemy until reinforcements could arrive.

7. The delaying action of an inferior force by taking up successive positions.

The problem proposed for solution was as follows:

*General Situation:* BULL RUN and OCCOQUAN CREEK form the boundary between hostile States. A Red force is at WOODBRIDGE guarding the railroad bridge and the crossing at that place. A strong detachment has been sent to MT. VERNON on reconnaissance.

A Blue force is at ALEXANDRIA with a small detachment in the vicinity of FORT HUNT.

There has been no contact thus far.

*Special Situation, Blue:* The Blue detachment at FORT HUNT consisting of the 104th and 119th Companies, under the command of Captain Ralston, has been guarding the docks at that place.

There has been considerable activity on the part of the enemy in the direction of MT. VERNON this afternoon, indicating a greatly superior force. This fact has been reported to higher authority and the following message is received by the detachment commander at 4:00 p.m.:

| | |
|---|---|
| Mounted messenger. | Detachment Blue Forces, ALEXANDRIA, 10 Oct. 12. 3:00 p.m. |

Commanding Officer,
Blue Detachment,
Fort Hunt.

Information received that a large force of the enemy is preparing to move on ALEXANDRIA. His activity in the direction of MT. VERNON is probably an advance detachment thrown out to cover his movements. This force will remain at ALEX-

ANDRIA for the present. Strong reinforcements are expected to arrive to-morrow.

March your command at 8:30 to-morrow morning via the 1—2—28—34—36—40—41 road towards ALEXANDRIA.

Do not allow your troops to become seriously engaged.

Send messages to ALEXANDRIA.

A......B......
Commanding.

REQUIRED: Carry out your orders.

*Special Situation* (*Blue*) *Continued:* On arriving at this point you receive the following message from the commanding officer at ALEXANDRIA:—

Detachment Blue Forces,
ALEXANDRIA, 11th Oct. 12. 8:20 a.m.

Commanding Officer,
Blue Detachment,
On ALEXANDRIA—FORT HUNT road.

No further information of the enemy. Our reinforcements are arriving rapidly. We will have a large force ready to advance to-morrow. Halt your command and bivouac in the vicinity of the WATER TROUGH and await further orders. Keep in touch with the enemy by means of patrols.

Send messages to ALEXANDRIA.

A......B......
Commanding.

REQUIRED: Carry out your orders.

*Special Situation* (*Blue*) *Continued:* Blue reconnoitering patrols have been in contact with the enemy this afternoon.

(Use any information that may have been gained.)

At 4:00 p.m., a message is received from the detachment commander at ALEXANDRIA, the body of which reads as follows:

"The activities of the enemy in the direction of LORTON and POHICK indicate an early advance. His patrols have been reported as far north as ACCOTINK STATION. Our forces will advance to-morrow towards FRANCONIA and ACCOTINK STATION by the FAIRFAX and TELEGRAPH roads, respectively. Reinforcements of two companies should reach you by 11:00 a.m., to-morrow.

"March your detachment at 7:40 to-morrow morning. Take up a position on the high ground west of the NORTH BRANCH of HUNTING CREEK covering the MT. VERNON road. Oppose any advance of the enemy.

"Send messages to ALEXANDRIA."

REQUIRED: Carry out your orders.

*Special Situation, Red:* The Red force at MT. VERNON has pushed forward to FORT HUNT, a detachment consisting of the 44th, 47th, 143rd and 17th Companies, under the command of Captain McMillan, with orders to destroy the docks at that place.

The mission has been accomplished and a report to that effect made.

At 4:00 p.m., 10th October, a message is received from the commanding officer at MT. VERNON, the body of which reads as follows:—

"It is reported that a strong force of the enemy is at ALEXANDRIA, preparing to move south. We will remain at MT. VERNON for the present. The trolley bridge at RIVERSIDE will be destroyed to-night.

"March your detachment at 8:00 a.m., to-morrow towards MT. VERNON via the 1—2—4—25—24—17—16—14 road.

"Send messages to MT. VERNON."

REQUIRED: Carry out your orders.

*Special Situation, Red, (Continued):* On arriving at this point you receive the following message from the commanding officer at MT. VERNON:

Detachment Red Forces,
MT. VERNON, 11 Oct. 12. 8:20 a.m.

Commanding Officer,
Red Detachment,
On MT. VERNON—ALEXANDRIA road.

No further information of the enemy. Our main body will advance to ACCOTINK to-morrow. Trolley bridge at RIVERSIDE destroyed last night.

Halt your command in the vicinity of 16. Bivouac and await further orders.

Keep in contact with the enemy by means of patrols.

Send messages here.

C....... D.......
Commanding.

REQUIRED: Carry out your orders.

*Special Situation, Red, (Continued):* Reconnoitering patrols from the Red detachment have been in contact with the enemy this afternoon.

(Make use of any information that may have been gained.)

At 4:00 p.m., a message is received from the detachment commander at MT. VERNON, the body of which reads as follows:

"It is reliably reported that a force of the enemy is preparing to move southwest from ALEXANDRIA. Our main body will march to-morrow via ACCOTINK towards FRANCONIA to cover working parties destroying the R. F. & P. Railroad north of ACCOTINK STATION.

"This detachment will act as a right flank guard, advancing to-morrow forenoon to a position on the ACCOTINK—ALEXANDRIA road.

"March your command at 7:30 a.m., to-morrow, in the direction of ALEXANDRIA and drive back any small forces of the enemy that may be on the MT. VERNON—ALEXANDRIA road.

"Messages will reach me at 16 after 8:30 a.m. to-morrow."

REQUIRED: Carry out your orders.

This exercise was conducted, in all its details, just as planned.

* * * * * *

*Meeting Engagement: Red and Blue*

[Description omitted because of the necessity for omitting the maps, without which the description is without value.—*The Editor.*]

A conference was held on these operations at 11:30 a.m., Sunday, 13 Oct. A large scale map was prepared for the occasion. The commanders of the two forces explained their movements and intentions. The operations were then discussed by the umpire. The tactical errors were pointed out and discussed in detail.

SUNDAY, 13 OCTOBER

All the troops of the command were formed in full field equipment and inspected by the camp commander. A thorough inspection of the camp was also made.

11:30 a.m.: Conference on the operations of 11 and 12 October.

MONDAY, 14 OCTOBER

A. M.: Pay day for the troops.

P. M.: It was intended to solve problem No. 3—attack and defense of a position. This exercise had to be postponed on account of rain.

TUESDAY, 15 OCTOBER

A. M.: Problem No. 3. Attack and defense of a position.

Map: Fort Hunt and Vicinity.

This problem was designed to illustrate the following tactical principles:

BLUE

1. The process of taking up a defensive position to defend an important point.

2. The method of retiring from one position to another in rear, fighting delaying actions at each place in order to gain time.

3. The method of covering the main defensive line by means of covering detachments, thus compelling the enemy to deploy at a distance.

RED

1. The march of a column in close proximity to and being held in a state of constant readiness to attack the enemy.

2. The method of delivering an attack where time is the most important factor, i.e., no time available for wide turning movements.

3. The method of continuing an attack once begun to keep the enemy on the run and prevent his taking up successive positions.

The following is the problem proposed for solution:

*General Situation:* The Potomac river forms the boundary between hostile States. A Blue force is in the vicinity of BRANDYWINE. A Red force is at ALEXANDRIA. Contact has not yet been gained.

*Special Situation, Blue:* A Blue detachment consisting of three companies of infantry has collected supplies from the surrounding country and assembled same at FORT HUNT. Early on the morning, 15 October, a reliable spy reports that a strong force of the enemy is preparing to move on FORT HUNT with a view to capturing the supplies before they can be removed to FORT WASHINGTON.

At 7:50 a.m., you receive a message from the detachment commander, the body of which reads as follows:—

"It is reliably reported that a strong force of the enemy is advancing from the direction of ALEXANDRIA for the purpose of collecting the supplies we have collected here. The removal of these supplies to FORT WASHINGTON will be completed by noon to-day.

"Captain McMillan, with the 44th and 47th Companies will take up a defensive position in the vicinity of GRASSYMEDE, covering the NECK ROAD and other avenues of approach

from the north. Holding the enemy off until the supplies can be removed from FORT HUNT.

"I remain at FORT HUNT."

REQUIRED: Carry out your orders.

NOTE:—The messages that would be sent back to FORT HUNT will be written out and handed to the umpire at the conclusion of the exercise.

*Special Situation, Red:* A report has been received that a small detachment of the Blue forces crossed the POTOMAC for the purpose of collecting supplies in the vicinity of FORT HUNT.

Your detachment, consisting of the 17th, 104th, 119th and 143rd Companies, has been sent out from ALEXANDRIA to expel the enemy and capture or destroy any supplies that he may have collected.

When you reach this point (38) you meet a friendly inhabitant. After carefully questioning him you obtain the following information:—

"Several companies of the Blue forces crossed the river yesterday and collected a puantity of supplies in this section of the country. They have assembled same at FORT HUNT and are preparing to take them to FORT WASHINGTON. With the transportation available I should say it will take until noon. I saw a small force moving out from FORT HUNT about an hour ago—do not know where they stopped."

REQUIRED: Carry out your mission.

NOTE: Troops participating in this exercise are positively prohibited from securing any information from the inhabitants of the country.

P. M.: Problem No. 4. Attack and defense of a position.

Map:—Fort Hunt and Vicinity.

This problem was designed to illustrate the following tactical principles:—

BLUE

1. The taking up of a defensive position with a view to a stubborn defense of same, to cover the disembarking of a larger force.

2. The selection of the defensive line. The deployment. Method of covering the front by covering patrols. Handling of reserves. The method of withdrawl from such a position.

RED

1. The method of attacking a position which has been deliberately taken up. Driving in the covering detachments

and developing the main line of the position. Conduct of the firing line. Fire control and direction. Handling of reserves.

2. The occupation of a position after it has been captured. Formation for meeting a counter attack.

The following is the problem proposed for solution:

*General Situation:* The Potomac river forms the boundary between hostile States. A Red force is at ACCOTINK STATION. There has been insistent reports that the Blue army is preparing to invade Red territory.

*Special Situation, Blue:* A Blue force has been sent forward to Riverview, Maryland, with orders to cross the POTOMAC RIVER and secure the landing at SNOWDENS.

One battalion consisting of the 44th and 119th Companies under the command of Lieut. Thompson has crossed the river with orders to move out and take up a defensive position to cover the crossing of the remainder of the force.

A report has been received that a Red force is marching on FORT HUNT from the direction of ACCOTINK.

You, Lieutenant Thompson, are in command of the provisional battalion, BLUE, consisting of the 44th and 119th Companies.

REQUIRED: Carry out your mission.

*Special Situation, Red:* A Red force consisting of the 17th, 47th, 104th and 143rd Companies, is one of several detachments sent out for the purpose of preventing the Blue forces from gaining a foothold on the west bank of the POTOMAC.

On arriving at this point (25) a friendly native is met, who gives the following information:

"Two companies of Blue troops crossed the river to-day at SNOWDENS LANDING. There seems to be a considerable force in the vicinity of RIVERVIEW preparing to cross. The two companies were marching out towards (28) when I saw them."

You, Captain Wilson, are in command of the Red Force.

REQUIRED: Carry out your mission.

7:30 p.m.: Conference on problems Nos. 3 and 4. Attended by all officers and non-commissioned officers. A large scale map was prepared for the occasion. The commanders on both sides were called upon to explain their action and intentions. A "solution" was prepared by the umpire and submitted for discussion. Tactical errors were pointed out and explained.

### Wednesday, 16 October

A. M. Exercise. Attack of a defensive position. Enemy outlined by a few men. Volume of fire of defense indicated by flags.

(This exercise is mentioned in par. 357, I. D. R.)

The exercise was conducted as follows:—

(A preliminary drill was held for the flag detail near camp Tuesday evening. All officers and non-commissioned officers were observers. The umpire explained the object of the exercise. The necessity for fire control and direction. The superiority of fire and the means of gaining it. The advance of the firing line.)

The defensive line was divided into two sectors. Six men with white signal flags were stationed in one sector and six with red signal flags in the other. Ten riflemen with a goodly supply of ammunition were placed in each sector. Two men with signal flags, one white and one red, accompanied the umpire. Three flag positions were indicated:

1. When the flags were waving the preponderance of fire rested with the defense. The attacking line confronting or covering that sector of the line had to take cover and increase its volume of fire before a further advance could be made.

2. When the flags were held steady in a vertical position the preponderance of fire rested with neither side and the firing line could advance by using the proper tactics. That is, advancing a few men at a time by rushes, while maintaining the volume of fire from the remainder of the command.

3. When the flags were down the preponderance of fire rested with the attack and the line could advance to the front.

When the flags in any sector of the defensive line were waving all the riflemen in that sector maintained a steady fire. When the flags were held steady, one half of the men in a sector kept up the fire. When the flags were down there was no firing from the defense.

The fire of the defensive line was controlled by the umpire by directing the bearer of the red or white flag accompanying him to wave his flag, hold it vertical or down. The red or white flags in the defensive line conformed to the signals of the umpires flags.

The troops of the command were organized into a provisional battalion of three companies at as near war strength as practicable. Three officers to a company.

The attacking line was formed, two companies in the firing line and one in reserve, at a distance of about 1200 yards from the defensive position. The umpire and his two signalmen marched in rear of the firing line. The troops advanced to the front and when at about 1100 yards from the enemy fire was opened.

The line advanced, taking into account the volume of fire from the defensive line as indicated by the position of the flags in the two sectors. Men were required to fall out to indicate casualties. At the proper time a charge was made and the troops were formed up in the captured position to resist a counter attack.

The exercise was most instructive, showing as it did: The difficulties of controlling the firing line. The necessity for fire direction. The necessity for thoroughly trained N. C. O's on the firing line. The value of cover. The formations necessary to be adopted in the advance of a firing line. The handling of reserves. The necessity for having a body of troops held well in hand to occupy a captured position.

P. M.: Troops broke camp and returned to their respective stations.

## COMMENTS AND RECOMMENDATIONS

The country in the vicinity of Fort Hunt, at this season of the year when practically all of the crops have been harvested, is admirably suited to small maneuvers of this character. The land owners, with one exception, seemed perfectly willing to have the troops operate over their land.

It is almost impossible to conduct exercises of this kind without causing some damage, especially to fences. The land owners should be assured that they will be justly compensated for any damage that may be incurred. A small amount of money should be made available to pay such claims.

It appears desirable during the course of the maneuvers to have the troops make at least one bivouac at some distance from their permanent camp. Money should be available for the hire of bivouac sites for this purpose.

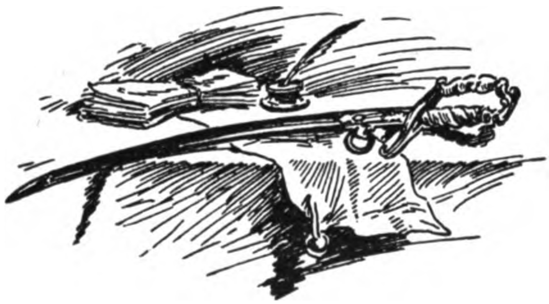
These troops should be supplied with the proper number of draft animals. Two per wagon are not sufficient to pull the loaded wagons over rough roads.

If it is intended to continue this class of instruction in the vicinity of Forts Hunt and Washington, a good map of the country should be prepared.

The tactical walks included in the first period of the instruction proved most instructive and beneficial in that they prepared the officers and non-commissioned officers for the duties that devolved upon them in the actual handling of troops in the exercise that followed. These walks may be extended to those involving the selection and preparation of a defensive position as well as making the plans for the attack of such a position.

It is believed that one or more companies of Regular Infantry should be sent to each artillery district during the conduct of the exercises. These troops should camp with the artillery troops and assist in their training in every manner possible.

The writer desires to express his high appreciation for the earnest co-operation and enthusiastic spirit displayed by the officers and enlisted men of the Artillery District of the Potomac who participated in these exercises.



# PROFESSIONAL NOTES

## TRINITROTOLUOL

During the past few years the most important development in explosives for naval and military purposes has been the almost universal adoption of Trinitrotoluol. For the bursting charges of projectiles it is rapidly taking the place of all other kinds of high explosives, whilst for mines, torpedoes and for destructive purposes generally it is superseding wet guncotton. Trinitrotoluol has been known in the arts for many years, and, in small proportions with other ingredients, it has been used for commercial blasting explosives and sporting powders. Its many advantages over the existing explosives (other than propellants) hitherto used for war purposes should certainly have been recognized earlier, but now that such recognition has been accorded it is astonishing with what degree of unanimity its adoption is rapidly becoming almost universal. The precedence of picric acid in its many forms, as, for instance, Lyddite, Melinite, Shimosé—all these being powders for the bursting of projectiles—is on the wane, whilst guncotton, wet and dry, is threatened in its departments of supposed exclusive usefulness as a destructive agent.

Already the new material has been adopted for all appropriate warlike uses by the majority of the Great Powers and smaller States. Those nations which have not yet taken definite steps are experimenting in such a manner as to leave but little doubt that they will shortly abandon their older high explosives in favor of Trinitrotoluol. It will be interesting at this critical stage of its development to examine and compare its characteristics with those of the explosives it is in course of replacing. In doing so care will be taken to avoid laying down very definite comparative figures with respect to certain of these characteristics. No matter how carefully certain experiments are carried out, it seldom occurs that results are identical. Personal error is necessarily present in the human part of the observations, whilst the particular apparatus employed may accentuate or minimize the behavior under investigation.

Subject to the above reservations, the following tabulated statement gives the results of comparative trials as carried out by a well-known scientific establishment. The most prominent of the high explosives used for warlike purposes have been brought under review in respect to the critical qualities of density, sensitiveness and, so far as is possible, efficiency of action.

The table [p. 96] shows that, compared with wet guncotton, Trinitrotoluol, whilst being much safer as regards shock, has the great advantage of what might be termed compactness. That is to say it may be compressed or cast to a much higher density, both intrinsically and in relation to explosive effect than the alternative explosive placed first on the list. In rate of detonation it is also superior, whilst the slight difference of expansive force in favor of the older explosive is covered several times over by its superior concentration of effect. The net result is that for a given weight or a given

volume of Trinitrotoluol it displays important advantages in two directions over wet guncotton. From the point of view of its employment in mines and torpedoes, and in slab or hose form for demolition purposes, it is evident that Trinitrotoluol possesses exceptional claims to serious consideration. It has a further advantage in contrast to the difficulties and objections associated with keeping wet guncotton under constant supervision, and in special packing to retain the correct percentage of water. Again, there is no analogy to the necessity for the use of a dry guncotton primer to detonate the wet guncotton.

Between Trinitrotoluol and the explosives based on picric acid (Lyddite being nothing more than cast picric acid), there is very little to choose from the point of view of explosive effect. The figures show that picric acid is, if anything, slightly superior in that respect, but, as regards safety, it is interesting to review the chemical and physical attributes of Trinitrotoluol in relation to the explosives with which it would naturally be compared.

| Explosive | Density | Fall of drop hammer (weight 2kg.) below and including which no explosion occurred with 0.1 gramme of Explosive | Rate of Detonation Meters per second | Gaseous products of Explosive Litres, per kg. | Lead block, nett expansion C. C.* |
|---|---|---|---|---|---|
| Dry Guncotton | 1.22 compressed | 5 centimeters | 6383 | 887 | 1810 |
| Wet Guncotton | 1.35 compressed | 40 centimeters | 5230 | 901.7 | 1400 |
| Picric Acid | 0.85 crystalline<br>1.62 cast<br>1.48 compressed | 20 centimeters | 8183 | 768 | 1520 |
| Trinitrotoluol | 0.90 crystaline<br>1.55 cast<br>1.62 cast under pressure<br>1.60 to 1.65 compressed | 80 centimeters | 7620 | 850 | 1485 |

* Dimensions of lead block: Diameter of block, 40 c.m. Borehole, 32 × 224 m.m. Charge, 50 grammes.

Special measures have always to be taken to prevent picric acid from coming into contact with certain metals, as it readily forms dangerous salts, that is picrates, especially lead picrate. Trinitrotoluol is free from these affinities. It is, moreover, practically non-hygroscopic, so much so, in fact, that bare blocks of it have been immersed in the sea for long periods, extending to several years, and on recovery have been detonated perfectly. On the score of comparative safety against shock, the high position of wet guncotton is discounted by the necessity to employ a primer of dry guncotton. Bearing that fact in mind, the table shows that the new explosive virtually stands alone in regard to safety. It has been found in practice that in the handling and loading of Trinitrotoluol, whether cast or compressed, the greater immunity from possible mishap can be taken advantage of in various ways. As a bursting charge for projectiles, its insensitiveness to shock has been demonstrated not only in connection with discharge from guns but also by its indifference to the shock of impact against armor plates. The last-named feature has been well illustrated by experiments where unfused projectiles have broken up in passing through an armor plate, without causing

detonation or even ignition of the Trinitrotoluol charge. A severer test for insensitiveness could hardly be imagined.

The introduction of Trinitrotoluol as an explosive for naval and military purposes has incidentally led to the development of an entirely new class of projectile, viz., a combined shrapnel and high explosive shell. This double-function shot can be used either as a time shrapnel for bursting in the air in the ordinary way or as a high explosive shell burst ng alternatively in the air or on impact. Such a consummation has hitherto been impossible, because picric acid, in the form, for example, of Lyddite, could not, for the chemical reasons already given, be permitted to come in contact with the lead shrapnel bullets. Trinitrotoluol happens to be an entirely innocuous substitute for the resin in which shrapnel bullets are embedded. This replacement of inactive material by a bursting charge has removed the only obstacle in the way of an improvement, long foreseen but rendered impossible by practical restrictions.

This combined shrapnel-high explosive shell thus contains an ordinary black powder bursting charge in the base, a separate head containing Trinitrotoluol, and a body containing lead bullets embedded in Trinitrotoluol. The separate head also contains a small quantity of smoke producing composition. A special time and percussion fuse completes the projectile. Its action is as follows:—The time portion of the fuse ignites the black powder charge in the base, so dispersing the bullets contained in the body and also causing disassociation from the separate head. Under these conditions the Trinitrotoluol in the body does not detonate, but functions exactly the same as the resin formerly did; the separate head continues on the line of trajectory and detonates on impact with a heavy dark smoke, thereby materially aiding the determination of range and time fuse length.

The shell can be readily adapted for use solely as a high explosive projectile, burst in the air to search deep trenches or well-covered works, or exploding on impact against buildings, etc. A device within the fuse cuts off communication to the black powder charge and so causes the high explosive in the body to detonate in unison with the charge in the head. The double system of charging enables a very powerful high explosive shell to become available as part of the equipment of field guns.

For demolition work by engineers, pioneers, cavalry, and for such work as boom destruction, Trinitrotoluol is very suitable, as not only can it be detonated with the usual detonators, but it can be packed into exceptionally handy forms. A favorite plan is to take a suitable size of compressed slab of it and electroliticallv deposit a skin of copper around it. The resulting charge requires no further packing, and can be carried in the pocket without preoccupation of mind. Danger is virtually non-existent, as Trinitrotoluol will not explode without a detonator, and even if lighted by a match it burns very sluggishly. The position as a whole may be summarized by admitting that when picric acid was first employed for the bursting charges of shells its conveniences and advantages were so great as to minimize the seeming importance of its defects. Those blemishes have become serious disadvantages ever since it came to be known that a substance is available which has all the good points of picric acid, but lacks the bad ones. Even if T.N.T., as it is customary to call it, showed marked inferiority in one or two of the directions where it is quite good, its chemical aloofness would alone suffice to secure its elevation to office.—*Arms and Explosives.*

# TRINITROTOLUOL, OR TROTYL*

## TORPEDO-CHARGES PREPARED WITH THIS EXPLOSIVE

By Lieut. Comdr. Guilherme Hoffman Filho, B. N.

(Translated by Commander A. B. Hoff, U. S. Navy, from the December number of *Revista Maritima Brazileira, 1912.*)

We have adopted this year, as the explosive for our torpedoes, trinitrotoluol, or TNT, in view of the enormous advantages that it offers in force, stability, etc., over guncotton. We have substituted, at the same time, for fulminate of mercury in the detonators a new explosive, hydronitride of lead.

### TNT OR TROTYL

TNT is obtained by the nitration of toluene, much the same as nitroglycerine is obtained by the nitration of glycerine.

Toluene is a liquid substance, colorless, boiling at 110° C. and is obtained by the distillation of coal tar. It is the first homologue of benzene, which it much resembles. For this reason toluene is also called methyl benzene. It was discovered in 1838 by Pelletier and Walter. It is found also, in the literature of chemistry, under the name "toluol," for which reason trinitrotoluene is also called "trinitrotoluol."

There are three known derivatives of toluene:

1. Mononitrotoluene............. $C_6\,H_2CH_5\,(NO_2)$.
2. Dinitrotoluene................ $C_6\,H_2CH_4\,(NO_2)_2$.
3. Trinitrotoluene................ $C_6\,H_2CH_3\,(NO_2)_3$.

It is to be noted that, during nitration, one or more atoms of hydrogen (H) are replaced by one or more radicals ($NO_2$).

*Mononitrotoluene.*—The mononitrotoluene is obtained industrially by treating toluene with a mixture of nitric acid at 40° Baumé and sulphuric acid at 60° Baumé. The nitration takes place in cast-iron vessels, cylindrical in form, and furnished with rotating paddles to keep the mixture in constant motion. After three hours of this digesting, the mixture is precipitated in water. The precipitate is first washed with alkaline water, and then with pure water. This precipitate is mononitrotoluene.

Just as during the nitration of glycerine the temperature never should exceed 30° C., so also in the manufacture of mononitrotoluene it should not pass beyond 50° C. To avoid a rise of temperature, the nitration vessels should have interior coils with a circulation of a cooling medium or liquid.

Mononitrotoluene is a solid substance, melting at 51° C., and was discovered by Saint Claire Deville.

Mononitrotoluene is not employed as an explosive by itself, but only in some mixture, such as Sprengel's explosives, Favier's explosive, etc.

*Dinitrotoluene.*—This derivative of toluene is obtained by prolonging the action of the nitric acid on the toluene, or by treating mononitrotoluene with this acid. This last process is adopted in all explosive factories that have been visited.

Like the first derivative of toluene, this also is a solid substance, melting at 70° C., and is slightly soluble in hot water and alcohol.

* Synonymous terms for this explosive are: Trinitrotoluene, trinitromethylbenzene, 'olite, trilite, trinol, tritone and trotol (Weaver's *Military Explosives*).—R. E.

The dinitrotoluene, also, is not employed by itself, but always in mixture. Triplastite is an explosive frequently used in mines. It is composed of dinitrotoluene and guncotton.

We have already had one opportunity of using this explosive (dinitrotoluene) in a progressive powder to augment the initial velocity of a projectile, and with very good success.

*Trinitrotoluene.*—Trinitrotoluene, finally, is obtained by the reaction of the mixed nitric and sulphuric acids upon hot dinitrotoluene. In actual practice it cannot be obtained directly by the action of acids on toluene, although so stated in some works on military chemistry.

Trinitrotoluene is *the* explosive *par excellence*, having been adopted by the majority of countries as the explosive charge in grenades, as well as in mines and torpedoes.

The first practical knowledge of this compound comes from Germany, where it is better known under the name of *Trotyl.* This abbreviation is the one adopted by our naval commission in Europe, and is the one which we will use henceforth.

Its first application as artillery ammunition dates from 1902.

Just as picric powders were given different names, so also trotyl has different designations.

Germany, in its military instructions, calls it trotyl; England, which adopted it in 1911, calls it TNT (trinitrotoluene); Spain, trytil; while others, as France, Italy, Turkey, etc., hold to the name trinitrotoluene.

### GENERAL PROPERTIES OF TROTYL, AND ITS ADVANTAGES OVER GUNCOTTON AS A TORPEDO-CHARGE

Trotyl is a definite chemical substance, crystalline, of a light yellow color which afterwards darkens to a deep brown, similar to picric acid. It is insoluble in cold water; undergoes no change in air; and can support, without inconvenience, the greatest variations in atmospheric temperature, between $-20°$ and $+50°$ C.

The neutral properties of trotyl, it will be seen, give it great advantages over picric acid. The latter, in virtue of its acid properties, forms metallic compounds, that is, picrates, which are very sensitive to shock. Lyddite (picric acid) has thus a great rival for gun-ammunition.

Kept submerged in water for many years, it does not lose its explosive force. Nor does it happen, as in the case of guncotton, that the greater the percentage of water the less the explosive force. Even in inflammability it does not suffer.

By means of gentle heating one can melt trotyl upon an iron plate without igniting it. Violent heating produces ignition. It burns slowly, however, without exploding, and with a black flame rich in carbon, similar to that produced by kerosene. Who would care to make this experiment with guncotton?

Placed on a cherry-red plate, trotyl burns slowly. Its great insensibility to shock, friction, and pressure makes it particularly appropriate for a military explosive. The shock produced by an 8-mm. rifle-bullet, with a velocity of 850 meters at 20 m. distance, going through a block of cast trotyl, does not cause the slightest alteration in it.

The pressure supported by trotyl in making up charges is 3000 kg. per sq. cm. The friction and attrition produced by a steel saw has no influence

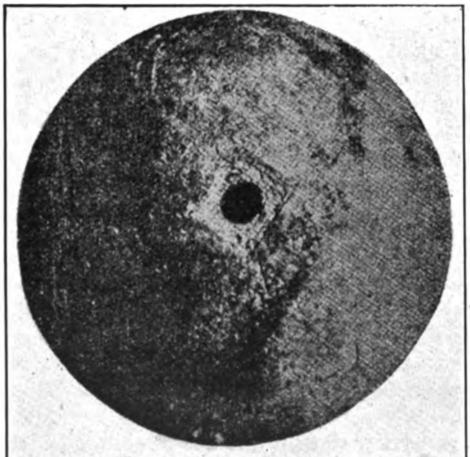
whatever upon it. This is a very common operation in the manufacture of trotyl. Trotyl can also be turned in a lathe, like a block of wood.

Making a technical comparison as to the resistance to shock of different explosives, detonated by the percussion test in an impact testing machine, the hammer weighing 2 kg., we have:

Dry guncotton explodes at a height of....... 5 cm.
Wet guncotton explodes at a height of.......50 cm.
Picric acid explodes at a height of...........20 cm.
Trotyl explodes at a height of..............80 cm.

Comparing the foregoing, we see that the insensibility of trotyl is four times greater than that of picric acid, and twice as great as that of the 20 per cent wet guncotton used in torpedo warheads.

By the above comparison we can also see the great sensitiveness of dry guncotton, used as the priming charge in our torpedoes.



TRAUZL'S LEAD BLOCK.

1298

The density of loose trotyl is 0.75; of cast trotyl, as used in charges, 1.61; and of compressed trotyl, 1.50. The greatest density to which guncotton can be compressed is from 1.36 to 1.40, containing 18 per cent to 20 per cent of water, a great density in the compression constituting a grave peril.

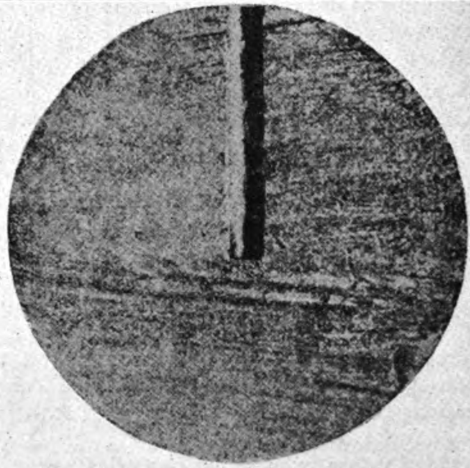
Pure trotyl melts at 80.°6 C., with considerable increase in volume, but without decomposition. Its specific gravity, when recrystallized in alcohol and dried, is 1.7, the same as of picric acid.

From all this we can deduce that a 45-cm. torpedo whose charge is 110 kg. of guncotton will contain, in the same volume, 127 kg. of trotyl. As a factor of density we have, as a consequence, the lessening of the distance from the center of explosion of the charge in relation to the object destroyed, which gives a greater effect to the charge.

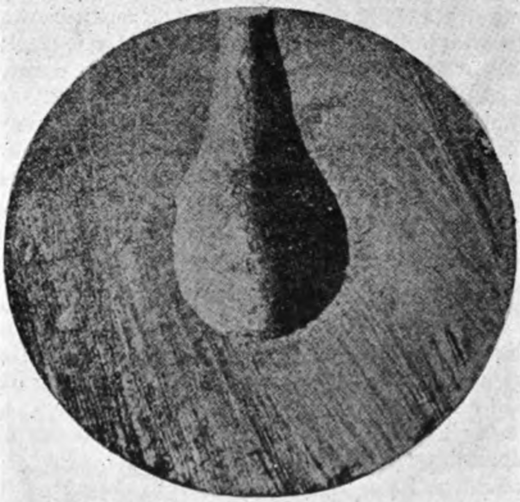
Comparing again the two explosives used to-day in our navy in torpedo-charges, let us note more differences as to the velocity of detonation and force of explosion, important factors from the military point of view.

Let us determine experimentally the velocity of propagation of the detonation, by measurement in an iron tube.

| | |
|---|---|
| Trotyl (compressed) | 7.620 m. per sec. |
| Wet guncotton | 5.228 m. per sec. |
| Dry guncotton | 6.383 m. per sec. |



SECTION BEFORE FIRING.



SECTION AFTER FIRING.

1299

Now it is known that the greater the velocity of detonation of a high explosive, the greater will be its effect. Our trials of the explosive force of trotyl have turned out most favorably. It produced in the Trauzl spherical

block of lead (40 cm. in diam.), with a charge of 50 grams, an excavation of 1485 cc., and with 20 per cent wet guncotton, 1400 cc. From these trials we conclude that the effect or explosive force of 45-cm. torpedoes charged with trotyl is much greater than that of the same charged with guncotton, for the following reasons:

1. Ability to increase the weight of charge in given space.
2. Diminution of distance from center of explosion.
3. Greater velocity of detonation.
4. Greater explosive force*

The chemical stability of trotyl is "unlimited"; on the contrary we all know the instability of guncotton and the dangers attendant upon its decomposition. In addition to regular inspections for both, we still have, in the case of guncotton, the special conditions of its care, preservation, and storing in magazines.

Loaded torpedoes, carried on board during action, constitute a serious danger. Trotyl, as a charge, lessens this. A projectile detonated in contact with a charge is almost certain to explode it. This will happen with any kind of torpedo-charge. But in the case of trotyl, its slight sensitiveness prevents this explosion, if the projectile explodes a little way from it. For the same reason splinters are not dangerous to trotyl charges. A torpedo, with a detonator in place, constitutes a danger, because the shock of splinters can produce a detonation. Guncotton charges are more sensitive and detonate more easily.

The percentage of water (from 18 per cent to 20 per cent) in guncotton charges, necessary to reduce their sensitiveness, is an inconvenience. When in store, the water in the charges slowly deposits itself in the lower part of the charge, forming strata of different density, which condition sometimes results in partial detonations. The compression of guncotton in single blocks should therefore be abandoned, as the dislocation of water is easier, and irregular densities will ensue.

The partial mine and torpedo explosions that occurred in the Russo-Japanese War are attributed to this irregular density in the charges. England, as a consequence, immediately abandoned the compressing of guncotton into a single block.

In charges of trotyl, the total mass is homogeneous, and does not absorb moisture, dispensing entirely with any inspection for this cause.

### THE TECHNICAL REQUISITES TROTYL SHOULD SATISFY FOR MILITARY USE

The chemical purity of trotyl is one of the principal factors favorable to its military application, and for this reason it ought to fulfil a series of technical specifications.

Trotyl, being a product of nitration, can contain as impurities both nitric and sulphuric acid.

*Determination of Nitric Acid.*—In order to determine the presence of this acid we must resort to a most sensitive reagent—diphenylamine.

Boil 10 grams of trotyl with 50 cc. of distilled water. Filter the cooled solution, adding fresh water to make up 50 cc. Take 5 cc. of this and dis-

* General E. M. Weaver, U. S. A., in the preface to his *Military Explosives*, 3d Edition, states that TNT will not stand the shock of impact, and therefore passes from the class of shell-fillers. He states that its relative explosive force is 119,000 lbs. per sq. in., as compared with that of picric acid 135,800 lbs., and of Explosive D 124,600 lbs.; and also that it is more sensitive to shock than Explosive D.—R. E.

solve it in a porcelain dish with 0.1 cc. of a solution of sulphuric diphenylamine (1:100) and 20 cc. of concentrated sulphuric acid. After five minutes the liquid, in its reaction, becomes violet, if nothing is wrong, and this reaction ought not to be stronger than the reaction obtained with a standard solution that contains 0.004 nitric acid per litre.

The standard solution is prepared as follows: 0.640 grams of potassium nitrate are dissolved in 1000 cc. of distilled water, and 10 cc. of this are again diluted in 1000 cc. of water.

*Determination of Sulphuric Acid.*—Boil 10 grams of trotyl in 250 cc. of distilled water. Leave it to cool and filter it. Draw off 100 cc. of the previously filtered solution and acidulate it with some drops of hydrochloric, and precipitate it with a solution of barium chloride (1:10). There will result the formation of a precipitate. This calculated in $SO_3$ ought not to exceed .05 gram in 100.

*Foreign Substances.*—Dissolve 50 grams of trotyl in 200 cc. of hot benzol, and filter. The weight of the residue from this filtration ought not to exceed 0.10 grams in 100. The resulting ashes from calcination ought not to exceed 0.9 grams in 100.

The nitrogen determined by Kjedahl's apparatus ought not to be less than 18.30 per cent.

*Point of Solidification.*—Trotyl, previously dried, is placed 30 mm. from a Bunsen burner, and melted in a test tube. The amount of melted trotyl should be sufficient to cover the thermometer bulb for 2 cm. During cooling the degree of temperature should be observed, noting that before complete solidification, the thermometer rises a little, after remaining steady.

The temperature of solidification ought not to be below 79.°5 C., which corresponds to the fusing-point of pure trotyl (80.°6 C.).

The temperature correction indicated by the thermometer is made after the following formula:

$$K = \frac{n(T-t)}{6300},$$

signifying—

$K$ = correction in degrees.

$n$ = number of degrees of the thermometer above the melted mass.

$T-t$ = difference between temperature of air and of fusion.

*Density.*—For cast trotyl the density ought not be less than 1.6; and for compressed, not less than 1.5. This should be determined by the flask method or the relation between weight and volume.

*Moisture.*—Place two samples of the pulverized trotyl in a furnace at 50° C. After four hours the difference in weight ought not to be greater than 0.1 per cent.

### BLEIAZID OR NITRIDIDE OF LEAD

Up to the present time, fulminate of mercury has always been used for detonators in torpedo-charges. The fulminate alone was first used in military pyrotechnics. Afterwards it was mixed with other explosive nitrates, such as trotyl, picric acid, tetranitromethylaniline, etc., in order to increase the force of the initial impulse.

In navies, principally, the fact that fulminate of mercury is very porous and cannot explode when wet is a great inconvenience. That is, its easy absorption of moisture, due to its porosity, makes it decrease in density.

This new explosive (nitridide of lead) was introduced two years ago in military-explosive work, thanks to the labors of that eminent German chemist Dr. Lothar Wöhler of Darmstadt, who applied it to detonators.

*Bleiazid*, a German word made up of *Blei* (lead) and *azöe* (nitrogen), has the chemical formula $PbN_6$. It is a derivative of lead and hydrazoic acid.* It may be called lead hydronitride.

We had the good fortune to be present at the first lecture of Dr. Wöhler, accompained by numerous practical experiments, at a formal meeting of the United Societies of German Chemists.

Concerning the discovery of hydrazoic acid in 1890 by Curtino, the illustrious chemist Bertholet says: "It is one of the most notable and long-wished-for discoveries of the present epoch."

Hydrazoic acid is a violent and very sensitive explosive, that explodes when exposed to intense light. Nevertheless it is capable of practical use.

Specialists in military explosives perserved in their research of the compounds of this acid until they arrived at the lead hydronitride. Leading in this crusade were the eminent chemists Bertholet, Vieille, Noelting, Dennsted, and finally Wöhler.

The later, in his lecture, practically demonstrated the greater velocity of reaction, in the detonation of lead hydronitride, over fulminate of mercury, as well as its superior resistance to moisture. This assurance of lead hydronitride resisting moisture, without losing its detonating effect, made it rapidly adopted as a detonator.†

In its natural state the sensitiveness of lead hydronitride to shock is the same as that of fulminate of mercury. Compressed, it is less sensitive in this regard than the fulminate. Its force of detonation, however, is twice as great. Hydronitride of lead holds its detonating properties, even when compressed at 6000 kg. per sq. cm., while fulminate loses this property at 700 kg. Lead hydronitride resists high temperatures better than its rival. It is insoluble in water, of a white color, and dust-like in appearance.

In making detonators, tetranitromethylaniline, or "tetryl" (not to be confounded with "trotyl"), is added to both fulminate of mercury and lead hydronitride. Tetryl is the abbreviation for tetranitromethylaniline. It

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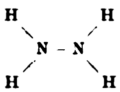
* This is undoubtedly $HN_3$, called by Curtino hydronitrous acid. Authority, Mendeleef. Some translators call it hydronitric acid—but it is believed they do so incorrectly—also hydrazoic acid and azoimide. It is hydrazine



n which three atoms of H are replaced by N, giving

and for this reason the name hydrazoic acid most clearly defines it.—G. W. Patterson.

Nitrohydric acid or hydrazoic acid, $N_3H$, is very explosive itself and forms highly explosive salts. It furnishes a remarkably great volume of gas. It has not as yet received any important practical application. *Wisser's Explosive Materials*, D. Van Nostrand Company, 1898.—R. E.

† That this material is to any extent in practical use as yet is considered doubtful, as there are many features about it that require considerably more experimentation. For example, the size of its crystals determines its sensitiveness. Cases are on record where even under water large crystals spontaneously explode, involving the whole mass in contact. Very fine crystals of it are less sensative than fulminate, but to make it a practical material may involve a larger share of experiment than this paper would indicate.—G. W. Patterson.

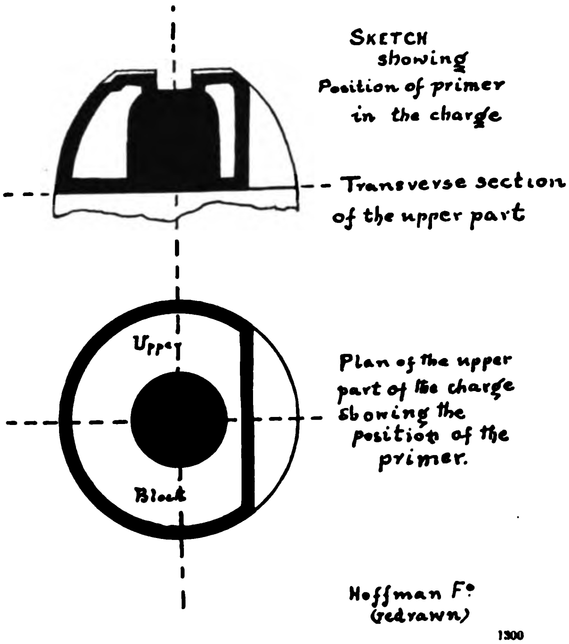
is a yellow explosive substance, insoluble, stable like trotyl, and is obtained industrially by the nitration of dimethylaniline.

### EXPLOSIVE CHARGE OF TROTYL FOR TORPEDOES. COMPOSITION AND CONSTRUCTION

I have given a description of the explosives that compose the charges of trotyl. We are now going to show how the whole charge is made up.

The charge of trotyl, like that of guncotton, is composed of detonator, primer, and explosive charge properly so-called.

*The Detonator.*—The detonator is composed of 1 gram of nitride of lead and 1.7 grams of tetryl. The manufacture is a secret, and its invention is protected by patents. The detonator is 7.5 mm. in diameter, and 50 mm.



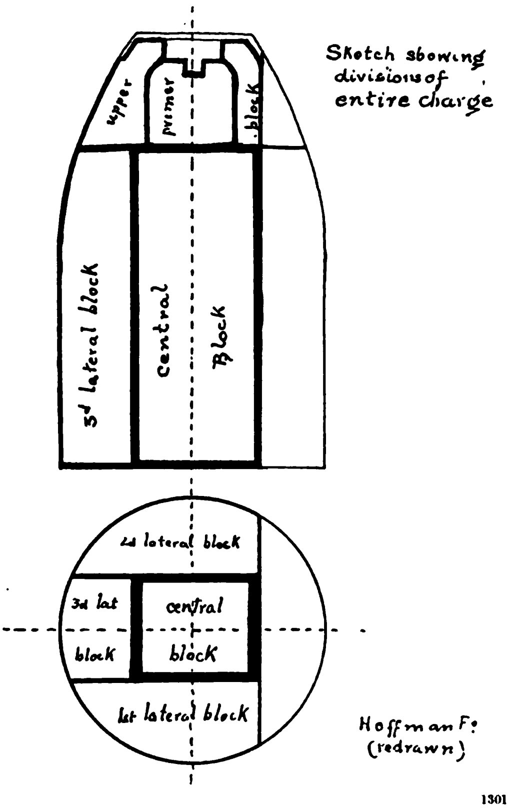

in length. In the acceptance tests of detonators not one should be permitted to fail, after being left eight days in air that is saturated with moisture, and afterwards detonated in an impact machine. All should detonate with a fall of hammer of 81 cm., equal in practice to a torpedo-speed of 4 meters per sec. The firing-point which causes the detonation ought to enter 15 mm., more or less, into the interior of the detonator.

A fulminate of mercury detonator is unable to satisfy the above requirements of moisture absorption.

*Primer Charge.*—The primer charge is composed of trotyl, compressed to a density of 1.5, having a cylindrical form with a diameter of 12 cm. and a height of 17 cm. Its upper part is in the shape of an ogival, as shown in our sketch. The compression of this charge is made at 2000 kg. per sq. cm.

In guncotton charges the primer is indispensable, but experiments show that, *compressed* trotyl being more sensitive to shock than *cast* trotyl, the detonation is transmitted with more facility and regularity to the main charge. Our sketch shows clearly the arrangement and position of the primer.

*The Charge Proper.*—The explosive charge, as shown in our sketch, is composed of five parts: an upper one, which takes the exact shape of the upper inside part of the head of the torpedo; a central part in the form of an oblong block; and others that surround the central part. The division of the charge, as well as the number of component parts, has no effect whatever on the explosive force of the war-head.




The upper part of the charge has set in it the primer, which is completely fixed to it, the whole forming one block only.

In the manufacture of the block the following is the procedure:

The trotyl is melted in a copper flask in a vapor bath. It is afterwards poured into small flasks, all alike, and cooled until it is about at the solidifying point of the trotyl. It is then compressed into a cast-iron mold of the exact configuration and dimensions desired, and in the determined position of the primer charge. The melted liquid trotyl is then poured into the form, the low temperature of which prevents further melting. At the end of twelve

hours draw the block out of the form, the block being by this time completely solidified.

The casting of the remaining parts is simple. Bring the form to the exact conformation of the blocks; melt enough trotyl; distribute it into the forms, and leave it. For the first few hours it is necessary to stir it, so that it does not crystallize and form air bubbles within the mass.

In order that the component parts of the charge shall be protected, the whole charge is electroplated* with a copper carton covering, whose thickness varies from 1/10 to 2/10 of a mm. This sheet forms a metallic envelope of chemically pure copper, and adheres closely to the trotyl. As an embellishment, the copper is chemically treated, producing the effect of *vieux cuivre*.

*Loading and Unloading.*—The loading and unloading of the torpedo war-head is most easy. Each block is pierced with two threaded holes, reinforced at these points by the copper electroplate. The handles which accompany the war-head permit withdrawl when necessary, with the greatest facility, by merely screwing them into the holes.

*Care and Preservation of Charges and Detonators.*—No especial precautions whatever are necessary relative to the care of trotyl charges. Their chemical stability is unlimited. Atmospheric temperature has no influence whatever on the charges, and it is thus practicable to keep them in any kind of magazine or storeroom.

It is advisable, however, to avoid high temperatures, in the interest of conservation, observing also the fusing-point of trotyl (80.°6 C.). High temperature expands the copper envelope of the charge, causing it to lose its adherence. This results in a loss of the effective military value of the envelope. A temperature of 45° C. as a maximum should be the standard practice.

In case of accident to the ship or flooding of storerooms, the trotyl charges suffer nothing of their explosive power, even if months under water.

The detonators (of $PbN_6$) ought to be cared for only as ordinary detonators.

The foregoing shows us that chemistry applied to the military art marches in these last years with gigantic strides. A few years ago the rudiments of chemistry were scarcely necessary to a comprehension of military pyrotechnics; to-day this subject cannot be studied without the most profound research into this science.

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EDITOR'S NOTE.—Germany, Russia and Brazil are reported to have adopted TNT for mines and torpedoes.

*Density.*—As crystals this is .8 to 1.0; melted, it is 1.5; and treated in special manner, it reaches 1.62. A pressure of 18 tons per square inch can be used when its density becomes 1.7. Picric acid can be subjected to 5 tons per square inch pressure, but its density fused or melted is high, 1.65.

*Comparisons with Other High Explosives.*—Picric acid or shimose stains the skin yellow, is very poisonous and difficult to work with, while it forms metallic salts that are very explosive and far more dangerous than the acid itself. The alkali picrates are practically as violent as fulminate of mercury. TNT is still under investigation in the United States. It does not stain the

* After the rigid specifications required for TNT, the wisdom of this procedure of copper plating it, using a liquid bath that is usually acid, seems somewhat questionable.—G. W. Patterson.

skin; is non-poisonous; forms no metallic compounds; is absolutely non-hygroscopic and perfectly stable, both physically and chemically; is not sensitive to blow, shock, or fire; when heated gradually it volatilizes with an explosion; however, it lacks sufficient oxygen for complete combustion.

Authorities.—C. E. Bichel, *Rivista di Artigliera e Genio*, I. Rudeloff.

The detonator—hydronitride of lead—has not been experimented with to any extent as yet, but possibly does offer a field if the results given in the article are accurate and the result of exhaustive experiments. It is not believed that as yet it is in practical use to any extent. As Mr. Patterson notes, however, its sensitiveness is too non-uniform as yet to make one certain of it.—*Proceedings U. S. Naval Institute.*

## COAST DEFENSE GUNS MOUNTED ON RAILWAY TRUCKS

There are here presented illustrations of a mobile coast defense battery of 200 mm. (7.87-inch) howitzers mounted on railway trucks, designed and manufactured by Schneider and Company, of France.

The idea of mounting artillery on railway trucks is attributed to General Peigné, who as early as 1883 suggested this system for the defense of coasts and fortified camps; but, while since that time some experiments have been made in various countries along the lines suggested, yet nothing of the kind has heretofore been placed on the market for use in coast defense. Schneider and Company now offer 6-inch short guns, 4.7-inch long guns, 6-inch howitzers, and 7.87-inch howitzers with appropriate cars for ammunition, all prepared to run on standard or special gauge railways.

France, Russia, Denmark, and Peru are said to have adopted the system or, at least, to have given orders for some of the material.

It is claimed that the system, in certain localities, is more efficacious and especially more economical than a system in which exclusive use is made of permanent fixed works. In many cases mobile batteries on trucks are sufficient by themselves for the defense of a long extent of coast and make it possible to dispense with fixed batteries between the *points d'appui*. Their great mobility enables these batteries to go rapidly wherever it is necessary to strengthen the defense, or to be withdrawn promptly and completely when no longer required or when it is necessary to escape the enemy's fire. The number of guns in a particular locality can be regulated to meet the exigencies of a particular time.

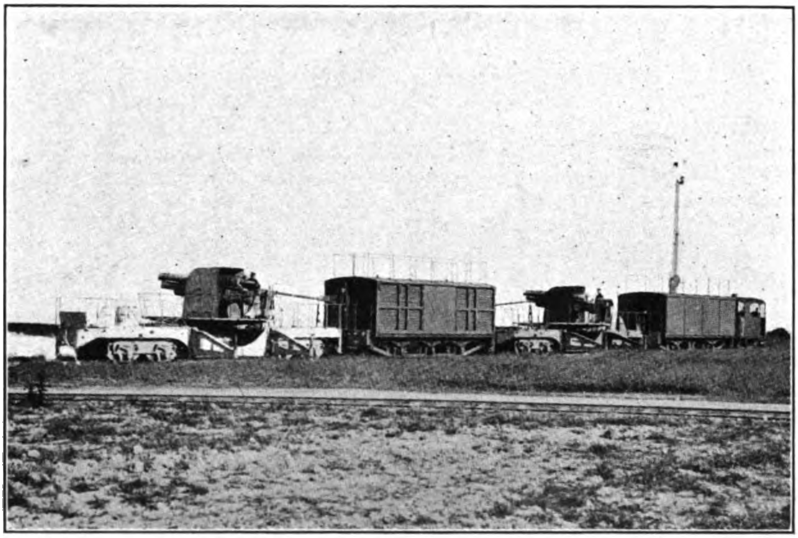
It is claimed that the mobility of the batteries constitutes an element of protection which is as useful as the ramparts of fixed forts; for the location of the latter is so well known to the enemy that he can direct his fire against them with considerable accuracy.

In brief, the advantages claimed are as follows:

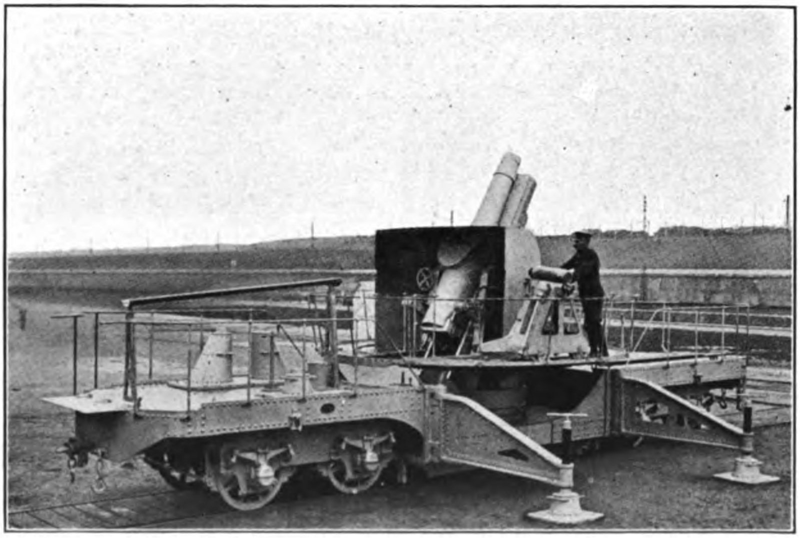
(1) Great economy in the preparation for the defense of any place, as these mobile batteries cost less than fixed batteries and can be sent rapidly to threatened points from places where they are not needed. The only expense is the laying of rails.

(2) Entire security with regard to the plans of the defense, since no permanent works indicate where the points of this defense are located.

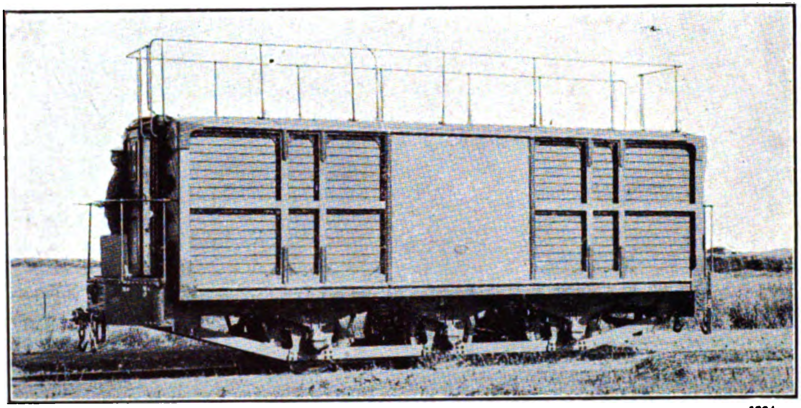
(3) Better utilization and economy of matériel, since no part of it will be immobilized at fixed points in permanent works.



MOBILE BATTERY OF 7.87-INCH R.F. HOWITZERS IN BATTERY 1302

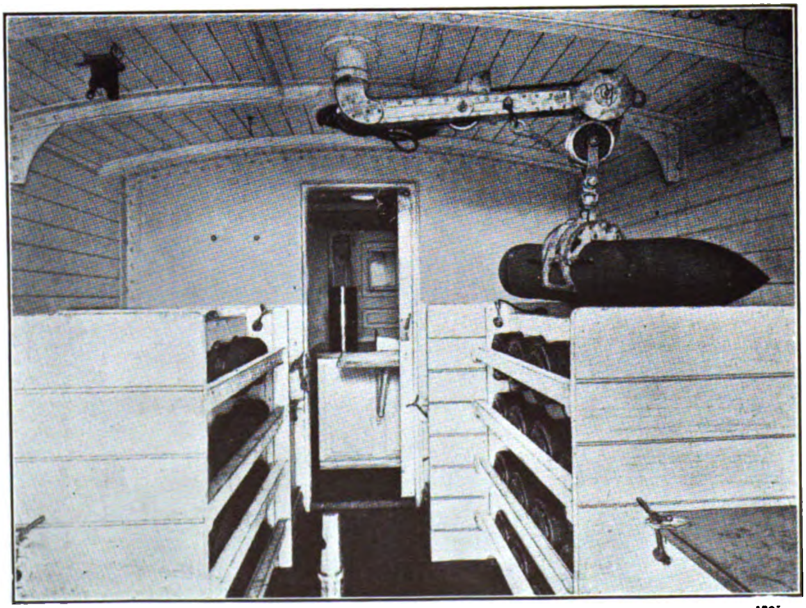


7.87-INCH R. F. HOWITZER ON TRUCK MOUNT 1303



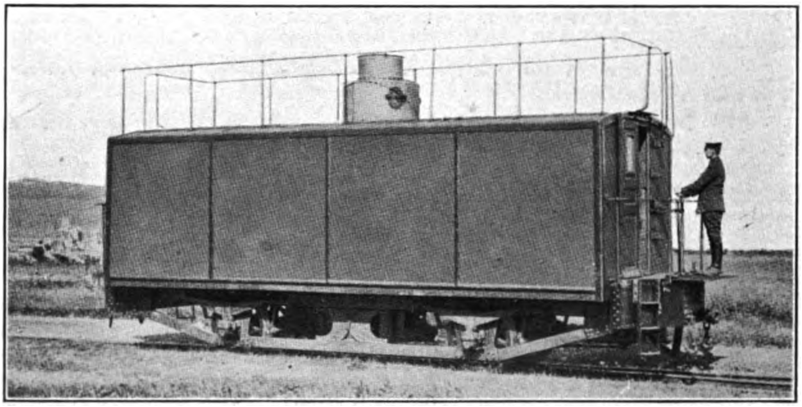
1304

AMMUNITION CAR
Exterior View

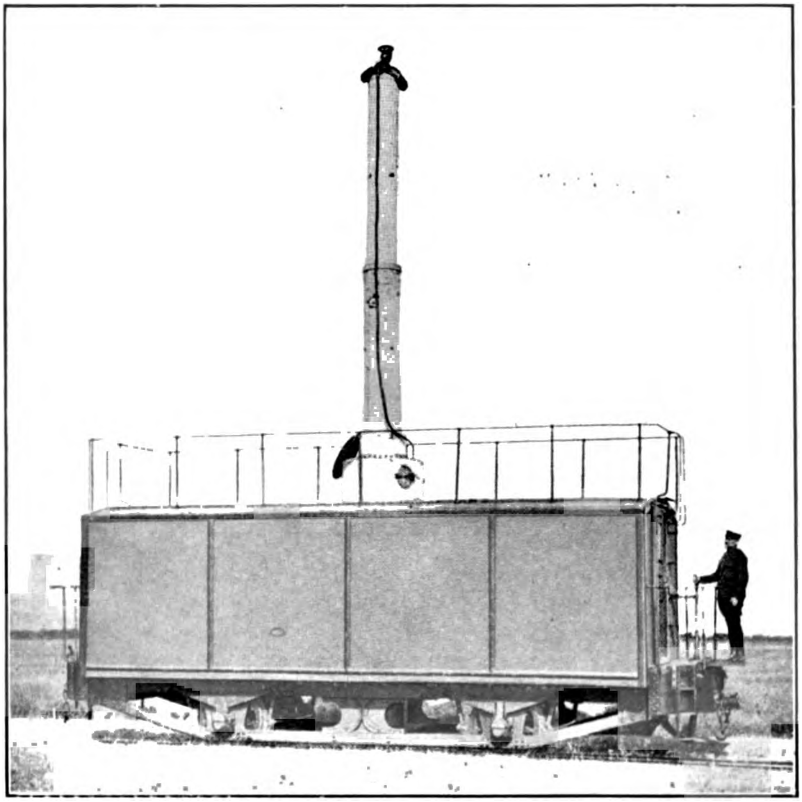


1305

AMMUNITION CAR
Interior View



PERSONNEL CAR WITH OBSERVATION STATION 1306
In Transit



PERSONNEL CAR WITH OBSERVATION STATION 1307
In Battery

(4) Ease of preservation of the matériel in time of peace as it can all be readily housed.

(5) Economy in the matter of building strategic roads for moving siege and field artillery.

(6) Outside of military uses, the railway built for coast or port defense can in time of peace be used for civil purposes.

## THE WATERBURY HYDRAULIC SPEED GEAR

The Waterbury Hydraulic Speed Gear is a machine for transmitting rotary power at variable speeds and in either of two directions without steps or abrupt gradations, while the source of power rotates continuously in one direction without any necessary change of speed. This source may be an engine of any kind, an electric motor, or a shaft of any rotating mechanism from which it is desired to transmit power. The medium of transmission is oil. This being practically incompressible, the driving is very positive, except to the extent of the very slight leakage necessary for lubrication. The gear has been successfully applied to such purposes as turret turning and gun training and elevating, for which its characteristics, uniform speeds and uniformly varying speeds in either direction without abrupt gradations, are especially desirable.

### Description

The complete transmission device is made up essentially of two parts, an oil pump designated as the A-end and an oil engine designated as the B-end. The A-end may be driven by any source of power and is supposed to run at a constant speed in one direction. By the turning of a small control shaft connected with this end the stroke of the pump pistons is varied at will to deliver oil to the engine, or B-end, at the rate necessary to give the required speed and in the direction called for. The control shaft may be operated by a handwheel placed at any convenient point and connected to it by wire rope or toothed gearing. The B-end is so constructed as to furnish a constant cylinder capacity per shaft rotation. The speed of the B-shaft is therefore definitely determined by the rate at which oil is supplied to the B-end by the pump. No oil is bypassed without doing its share of work in the B-cylinders. The leakage is very small, averaging about .13 of one per cent of the oil used in doing the work. There is practically no leakage from the gear as a whole; that referred to is what takes place between the high and low pressure parts of the mechanism. The speed ratios between the A- and B-shafts are, therefore, very positive and are definitely determined by the angular position of the control shaft in either direction from its zero, or neutral, position.

Fig. 1 is an external view of the gear in its most compact, or type C, form. In this type the A- and B-ends are combined into one working unit; the power enters the unit by the A-shaft which rotates at a constant speed, and is taken out by the B-shaft, at the opposite end of the machine, which rotates at any required speed and in either direction. The small vertical shaft shown in the figure at the A-end is the control shaft, and the direction of rotation of the B-shaft is determined by the direction the control shaft is rotated from its zero position and the speed of the B-shaft is determined by the angle through which the control shaft has been rotated.

On top of the B-end is an oil expansion box communicating with the oil in the machine. The whole enclosing shell of the gear is entirely filled with oil, although only a small portion of the oil is under pressure and active in transmitting power. The chief purpose of the expansion box is to provide for the difference of coefficient of expansion between the oil and the metal. The interior of the box is in communication with the air through a small hole in its lid; the general oil supply is therefore under only atmospheric pressure.

In Fig. 1 the A- and B-ends are united by a common valveplate, which is located across the middle of the machine and through which the oil is circulated between the two ends. This valveplate may be made in almost any shape, permitting the placing of the two ends at any angle or in any position with reference to each other. Indeed, each end may be provided

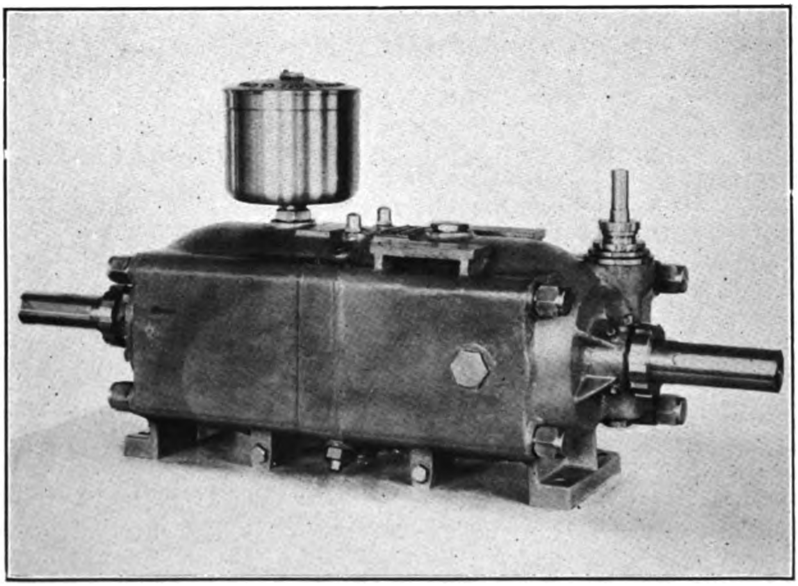


FIG. 1. 130M

with a separate valveplate and located in any desired position, the oil circulation being provided for by connecting pipes.

In Fig. 2 the outer cases are removed, leaving the internal parts, the two shaft groups being separated a little from the valveplate, and the angle and tilting boxes being pulled away from the socket rings.

### THE VALVEPLATE

The valveplate stands in the middle of the figure. It is also shown alone in Fig. 5. Passing through the plate about half way between its center and periphery are two semi-annular passages. These are for the circulation of the oil between the A- and B-cylinders. When the gear is transmitting power one of these passages is under pressure while the other is in suction. These two functions are changed according to the direction of rotation of the B-, or outgoing, shaft. Connected with the passages are three pairs of

valves: at the top are two small needle air-valves used only for the escape of air from the passages and cylinders while being filled with oil; at the bottom are two ball check-valves used for replenishing any leakage that may take place from the high pressure oil to the low pressure; at the bottom near the replenishing valves are two safety valves to provide relief should the gear be overloaded. There is also connected with each passage near the top a plugged hole for attaching gauges in case it is desired to measure the oil pressure, or load carried. Near the top of the valveplate, and also in connection with all the valves, there are holes passing through the plate giving free circulation of the oil between the two ends of the gear within the enclosing cases, or shells. There are also bolt holes for securing the cases. In the center of the plate are roller bearings for the inner ends of the shafts.

### THE SHAFT GROUPS

The shaft groups of parts in the two ends are almost identical. Figures 2, 3, and 4 may all be referred to in the study of these parts. A cylinder barrel is keyed slidably and rather freely to the inner end of each shaft. Each barrel has nine cylinders parallel with the shafts and fitted with pistons provided with ball ended connecting rods. The faces of the barrels slide in their revolution against prepared faces on the valveplate, and the cylinder ports in the barrel faces register with the semi-annular passages, except as they are passing over the separating lands at the top and bottom of the plate. The barrels are held lightly against the faces of the valveplate by spiral springs around the shafts, which are compressed between shoulders on the shaft and counterbored recesses in the barrels. These springs are only intended to hold the barre.s in position under no load. When the gear is transmitting power the barrels automatically support themselves, as will be mentioned later.

The piston connecting rods are formed with a ball on each end of each rod, one ball end being secured in a piston and the other in a socket in the socket ring.

The socket rings are connected by special universal joints with the shafts, so that while they revolve with the shafts, their planes of revolution may be at any angles to the shafts provided by the setting of the roller bearings on which the socket rings revolve.

### THE TILTING AND ANGLE BOXES

In the B-end of the gear the socket ring runs in what is called an angle box which is secured in the end of the case itself through which the shaft passes. It stands at a fixed angle of twenty degrees, giving a constant reciprocation to the B-pistons. In the A-end the box is hung on trunnions and may be adjusted to any desired angle, while the gear is running, by turning the threaded control shaft. The illustrations make clear the connection of the control shaft with the tilting box. As the load on the trunnions of the box is practically a balanced one, the turning of the control shaft is easy.

### OPERATION

The A-shaft, which is connected with the source of power, is supposed to run at a constant speed and in one direction. If the tilting box stands in its vertical or neutral position at right angles to the shaft, the pistons are carried around with the cylinder barrel but do not reciprocate. No oil is, therefore,

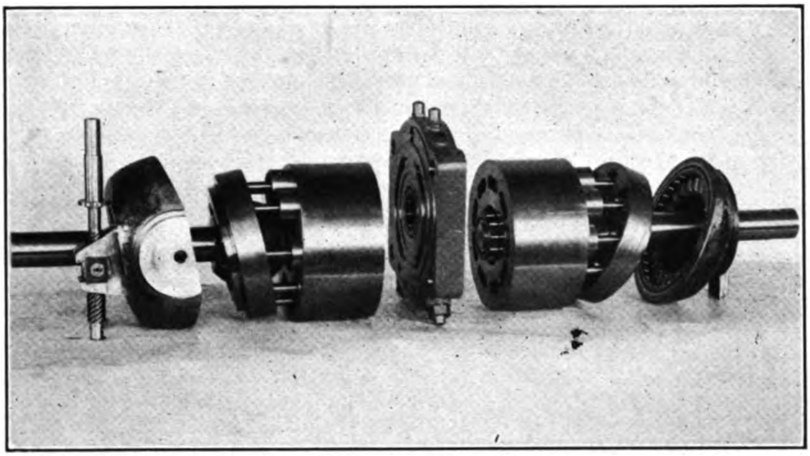
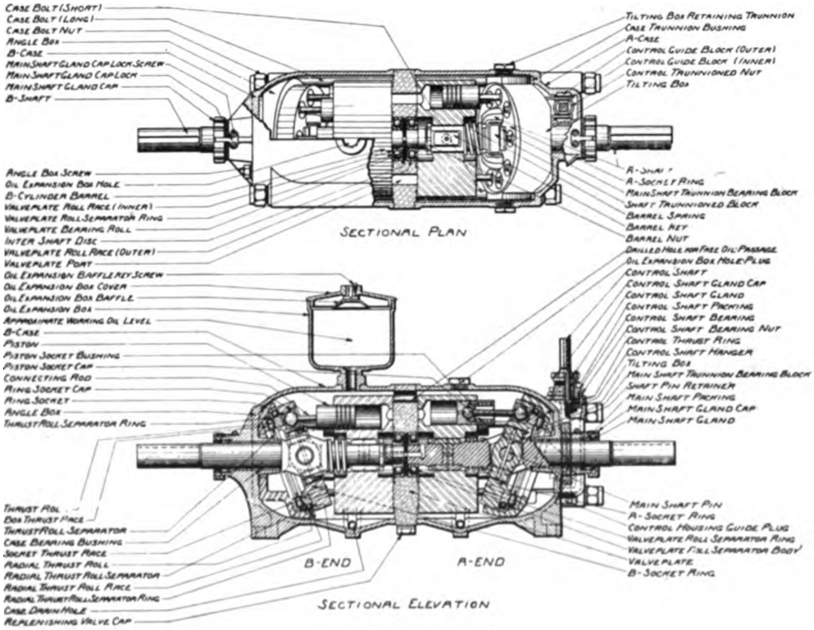


FIG. 2. 1309




FIGS. 3 & 4. 1310

taken from or delivered to the passages in the valveplate. If, however, the tilting box is inclined by turning the control shaft a little, the pistons reciprocate approximately to the extent of the sine of the angle of tilting multiplied by the diameter of the circle of centers of the sockets in the socket ring. Every cylinder during one half of the shaft rotation is in communication with one of the passages in the valveplate and is then receiving oil, which it carries across the land and delivers into the other passage during the other half of the shaft rotation. The amount of oil transferred from one passage

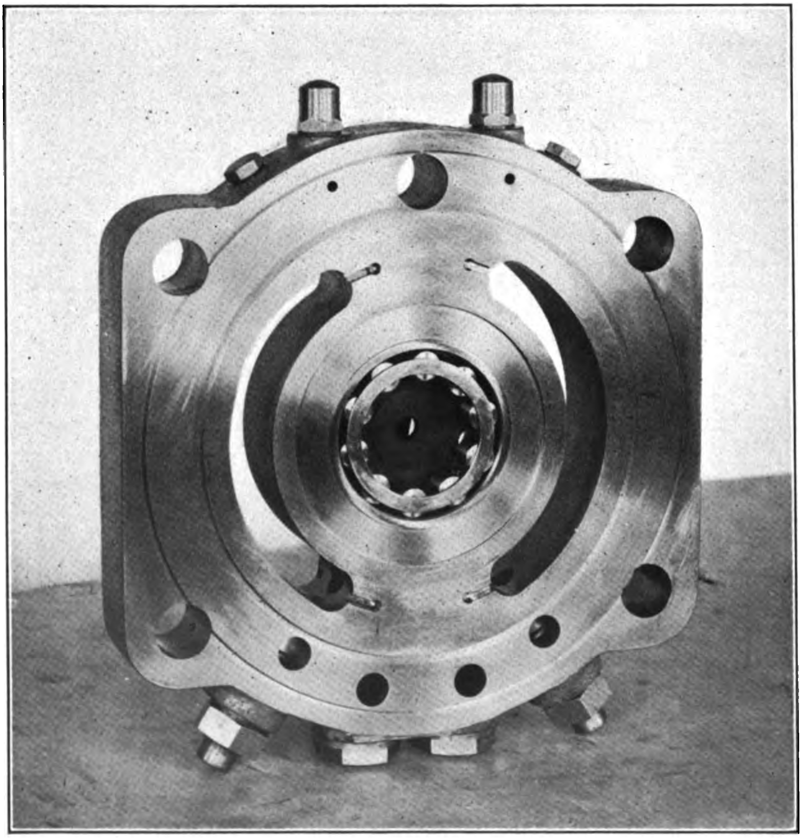


FIG. 5. 1311

across to the other passage depends entirely upon the displacement of the pistons. But there can be no transfer unless there is a supply to draw from and a space to deliver it into. These are provided by the cylinders of the B-end. When oil is being forced into one of the passages (already full) the pistons in the cylinders of the B-barrel in communication with this passage make room for the oil by sliding back from the valveplate; but they cannot do this without forcing their respective sockets in the socket ring farther from the valveplate. This can be done only by turning the socket ring as a whole in its inclined plane in the angle box. It must be remembered that

the B-socket ring, unlike the A-, is always inclined in its angle box twenty degrees, so that the B-pistons always reciprocate to their full extent at every rotation of the B-shaft. While the pistons facing the high pressure passage of the valveplate are receding to make room for the incoming oil and so imparting rotation to the B-shaft, the pistons facing the low pressure passage are moving towards the valveplate and delivering the oil from their cylinders through the low pressure passage into the suction cylinders of the A-barrel. Since the receiving capacity of the B-cylinders is constant and the delivery capacity of the A-cylinders is varied at will by turning the control shaft, the speed of the B-shaft is correspondingly varied. It will be seen that the only oil actively employed in transmitting power is that in the oil passages of the valveplate and in the cylinders. The enclosing outside cases merely serve as a retaining reservoir and are not subject to any pressure.

The oil pressure in the cylinders and valveplate passages varies directly as the torque resistance which the B-shaft must overcome. The horse power transmitted varies directly as the product of the oil pressure and the speed of rotation of the B-shaft. The normal working oil pressure ranges usually between 300 and 500 pounds, but it may rise to 1000 or even 2000 pounds to overcome an unusual resistance. In tests, pressures as high as 4000 pounds per square inch have been attained.

### Efficiency

The chief advantage of this type of transmission is its great flexibility. The B-shaft may be started under a dead load of any magnitude within the strength limits of the machine, without any fear of overloading the motor or source of power; the speed may then be increased gradually and positively to its maximum without steps or abrupt gradations. Its remarkable flexibility must necessarily give wide differences of efficiency. Under the best conditions efficiencies ranging from 85% to 91% are common; under average working conditions the efficiencies vary between 80% and 85%; under small loads and low speeds of the B-shaft the efficiencies range from 80% down to 50% or less. Of course at a zero speed, the horse power efficiency must be zero per cent while the torque efficiency remains at 95%, and so the horse power efficiencies have a wide range from 0% to 91%, while the torque efficiencies throughout the whole range remain between 90% and 96%.

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## DEFENSE OF FORTIFIED HARBORS AGAINST DIRIGIBLES AND AEROPLANES

By Major H. T. Hawkins, R. A. (Retired)

By way of clearing the ground, a few words are necessary on the relative value of the two principal descriptions of air-craft at the present moment.

### RELATIVE VALUES

There can be no doubt that the dirigible has made great progress lately, and may reasonably be expected to make more in the near future, whereas the evolution of the armed plane has been disappointingly slow, so that France, as well as England, has realized that the German airship of the

moment is a very formidable weapon of offense. France is now building dirigibles in haste, allowing it to appear that she does not consider her numerous planes a sufficient defense.

As an example of the power of the modern Zeppelin, one of their vessels on the 25th January covered 550 miles in 15 hours (attaining incidentally a speed of 46 miles an hour), and it must not be supposed for a minute that this represents her maximum range of action.

As is generally known, the great drawback to maneuver in the vertical plane is the loss of ballast and gas incurred in rising and falling, but a proposal has recently been made to use a gas for lifting which can be absorbed and stored, and given out again when required, and which is non-explosive. Ammonia gas has been suggested. Can such an innovation be carried out, and there seems to be no great difficulty in the way, free maneuver in the vertical plane, and freedom from danger of sudden destruction, either by accident, or a hit, are at once obtained. The first means comparative immunity from aeroplane attack, the second greatly lessened vulnerability from gun fire or bombs, so that the only worthy antagonist is another dirigible. Incidentally too, shot holes could be mended in mid-air by deflating damaged compartments in turn, as easily as punctures in a motor tire, and the power of doing without ballast would add to the weight of fuel and armament that could be carried.

The dirigible of the present day is formidable enough without these advantages.

The evolution of the fighting aeroplane has been delayed in France because, owing to its many excellent points, the Gnome-engined tractor screw has been almost universally used, and it is hardly too much to say that no plane with a tractor screw can be really serviceable for fighting. In England the Cody machine and others need but little modification to be efficient, but England has "specialized in delay," as was publicly stated the other day by a high authority, and is a long way astern. Nothing much seems to have been done to improve the power of the plane for night fighting even in France, and it is at night that the dirigible is most to be feared.

Taking the best types of each it is probably a fair estimate to say that the aeroplane in numbers, perhaps six or eight, should destroy the dirigible by day in the lower levels, say 4500 ft. and under, but that a dirigible which retains its power of rising to the higher levels 4500 to 12,000 should cut down its assailants with its machine guns and rifles as they struggle laboriously upwards. It is probable that not all the planes in England to-day could destroy one good dirigible by night.

### SCALE OF ARMAMENTS

At present then we must rely on guns for defense, and the only question that arrives is what expenditure is justifiable. It must be remembered that, although we must in the near future build an aerial fleet or cease to be an Empire, and it is granted that the proper opponent of the airship is the airship, still we need a special armament for immediate needs as a defense against existing threats, and even although that armament should be provided on a fairly liberal scale, it will not be wasted when our aerial fleet is in being, because the individual airship of the near future will be less vulnerable to guns than the present one, and any ship that should slip past our aerial fleet will want much more hammering than one of the present day. Besides

it is probable that air strategy will follow the lines of historical naval strategy, and that an era of cross-raiding will precede the era of fleet actions.

### DOCKYARD

No cast-iron rule can be laid down, but it is suggested that at least four fixed groups of vertical fire guns, disposed preferably to landward, should be provided for each important dockyard, and that the 4-inch or 4.7-inch gun should be chosen. Also that two mobile pieces about 3-inch caliber, mechanically propelled on solid tires at about 20 miles an hour, should supplement them.

### SEAWARD BATTERIES

The seaward batteries will eventually require vertical fire guns in proportion to their size and importance—perhaps two 3-inch guns to each battery of 9.2-inch guns, and so on in proportion—but no Power has airships enough at present to spare any for attack on coast batteries when such targets as dockyards and large cities are available. Nevertheless, it should be worth while to issue some machine guns at once. Rexer type would do, carrying as heavy a bullet as possible, to prevent aeroplanes from approaching too closely.

### SITING OF FIXED GROUPS

The fixed groups, two guns each, should be on the landward side because airships are more likely to approach from that side and so could be kept longer under fire, because they would be better placed to take advantage of search-lights, which might well be worked from existing installations on the sea front, and because the *débris* of their projectiles would fall to seaward when the target was getting over the dockyard, and it was necessary to use a high rate of fire at all risks. One realizes, of course, the necessary risks to the population of using guns at all, but a plain man can see no other possibility at present; had we kept our proper place in the van of scientific progress by judicious expenditure in the last few years, we might well have mobile aerial torpedoes worked by wireless currents, which would make the approaches of our dockyards as dangerous to dirigibles at night as the three mile limit is to hostile ships of the line! The civil population of course must be warned in time of war that they leave their houses after dark at their own risk.

### ARMAMENT

Groups might be about 2000 yards apart. The present guns are suitable as far as ballistics are concerned, but good mountings are essential. Every effort should be made to get 90° mountings for all aero guns, although they seem to be content with 70° or 75° on the Continent. The nearer the vertical the flatter the trajectory, and the better the chance of hitting; there seems no difficulty in designing such mountings except for arranging for recoil. It might well be advisable to sacrifice a little velocity if the result cannot be otherwise attained, or the differential recoil system adopted.

### AMMUNITION

This question was dealt with in R.A.J. September 1910, and there seems nothing much to add as so much must depend on experiment. If practice is likely to be good enough to put on a fair proportion of direct hits, H.E.

shell would be the best, if not, universal shell, and every projectile must be timed to burst before coming to earth if possible. It might not be possible when engaging a target at low altitude. Whether a smoke trail is to be insisted on, or not, must depend on experiment under all conditions of weather.

### SHOOTING

The crux is the invention of an autosight, which does not seem to be a difficult matter. If the apparatus were found to be too cumbersome to install on the mounting, it might be used separately, the gun being trained and elevated by electricity. The extra expense would be well repaid by increased accuracy over any other system, and one-gun groups might do. The advantage of having two guns is that if all R.F. arrangements break down, it is possible to get a bracket with time fuzes rapidly, or to open a rapid fire on the French field artillery system of one gun over and one under, altering ranges inwards without waiting to observe.

### LOOK-OUT

A good look-out, both national and local, is essential. The Navy would no doubt have special patrols about our coasts which are liable to the approach of dirigibles. Once reported a good estimate of their destination could be made by taking into consideration the time and direction of the wind. If the weather is too thick for them to be seen it is improbable that they will find their mark. Local lookout stations would require rough instruments of the astrolabe type as well as oriented charts. By combining two or three messages the officer at the guns would know exactly where to expect his target. Simultaneous messages would run "No. 1 station—Airship bearing S.E., altitude 40°, estimated distance 3 miles." "No. 2 station—Airship bearing S.S.E., altitude 35°, estimated distance 3½ miles"—and so on.

### MOBILE GUNS

Mobile guns would find many opportunities of usefulness. They might have to fill gaps in the fixed defenses, or they might be ordered to take position as far forward as possible on the line of the airship's advance, and keep her under fire as long as possible. They would have to be exercised from time to time so that the civil population would get to know them, and give them right of way as they do fire engines of the domestic type.

### SEARCH-LIGHTS

Lights will be a difficulty. There must be some lights to landward of the fortress no doubt, but no possible system could cover all the approaches by air. The seaward beams too, in their ordinary use for guarding against torpedoboats, would point out the position of the dockyard to aerial attack. It might be best to keep *all* lights covered until an alarm is given by patrol boats or inland look-out stations, but such a system is risky. *Experientia docet*, however, and our present rudimentary vessels, which might perhaps have been more appropriately named from the Chinese than the Greek alphabet, might at least represent hostile craft moving at low speeds over defended areas, and help to throw some light on the subject. If they can be seen one ought not to have much difficulty with a Zeppelin!

—*The Journal of the Royal Artillery.*

## THE INCREASE OF CALIBERS IN THE PRIMARY ARMAMENT OF MODERN BATTLESHIPS

While for a long time the 12-inch gun had been everywhere regarded as the maximum caliber for the primary armament of battleships, a very marked movement in favor of an increase of caliber has been manifested in recent years, and that movement is culminating to-day in either the actual manufacture or, at least, the design for the armament of every navy of guns of caliber greater than the one which hitherto has appeared to meet all requirements.

This general movement must, very properly, concern our naval office at a time when plans for our future units, both battleships and battle-cruisers, are being prepared. Our attention at present, as is well known, is being given to two 23-knot types, one 558 ft. long by 92 ft. beam, and the other 590.5 ft. long by 98.5 ft. beam, displacing respectively 27,000 and 32,000 tons; and with good reason the question presents itself as to what caliber should be adopted in order to afford the units the maximum fire effect.

The general change of opinion which has recently taken place relative to primary armament is to be attributed in part to the great increase of battle ranges, and in part to the practice of filling A.P. projectiles with high explosives; for a direct result of an increase of caliber is to increase considerably the effectiveness of the projectile styled A.P., which may be considered to-day as the only projectile of the primary armament of battleships.

The general tendency at the present time is to require projectiles, not only to perforate the heaviest armor now existing or foreseen, but also to carry a larger charge of high explosive. Now, it seems that at the battle ranges contemplated to-day, the 12-inch projectile is not equal to the double demand, because of its small caliber; while on the other hand, an A.P. projectile of larger caliber, because of the armor at present employed, would have to attack plates that are below its real power. The design of this projectile, therefore, will be capable of being made more that of an A.P. shell than that of an A.P. shot; that is to say, it will be able to carry a larger bursting charge than could be carried by a projectile that would have to perforate armor equal to the projectile's caliber, and this advantage will increase with the caliber adopted. The larger the caliber of the A.P. projectile, the principal means of offense of modern battleships, the better it will fill its double purpose: to perforate armor plate and afterwards to be ruptured by a large charge of explosive.

Opposed to those considerations, which lead to a choice of the largest calibers for the primary armament, however, must be recognized other considerations that tend to limit the caliber—such as weight and space, the importance of which in the construction of our modern leviathans is appreciated.

But, whatever may be said for the 12-inch gun, which was universally employed in the armament of ships of the *Dreadnought* type, and to which we have till now remained faithful, with the *Bretagne* class we have changed to the 13.4-inch; and other navies have gone even further, for their projects include 14-inch and even 15-inch.

We present in a table the characteristics of the calibers at present included in primary armaments.

From the figures given it appears that increasing the caliber from 12-inch to 14-inch and 15-inch gives a gain in muzzle energy of 48 and 75 per

## Characteristics of the Calibers included in the Primary Armaments

| | 12-inch gun. | 14-inch gun. | | 15-inch gun. | |
|---|---|---|---|---|---|
| | | light | heavy | light | heavy |
| Length in calibers | 50 | 40 | 45 | 40 | 45 |
| Total weight of gun, in pounds | 123,458 | 114,639 | 158,731 | 137,126 | 176,777 |
| Weight of the projectile, in pounds | 893 | 1,543 | 1,543 | 1,951 | 1,951 |
| Weight of the propelling charge, in pounds | 364 | 364 | 472 | 364 | 511 |
| Weight of the bursting charge, in pounds | 29 | 66 | 66 | 93 | 93 |
| Weight of 100 service charges (powder and projectile) as stowed | 135,583 | 200,619 | 213,846 | 241,404 | 259,041 |
| Weight of a two-gun turret, in pounds | 1,159,620 | 1,364,647 | 1,510,151 | 1,527,788 | 1,735,020 |
| Weight of a three-gun turret, in pounds | 1,518,969 | 1,840,841 | 2,120,825 | 2,061,301 | 2,380,968 |
| Muzzle velocity, in feet per second | 2,821 | 2,427 | 2,640 | 2,296 | 2,558 |
| Remaining energy at 6,562 yds., in foot tons | 25,501 | 36,486 | 43,901 | 43,255 | 54,715 |
| " " " 9,842 " " " " | 17,593 | 27,115 | 32,926 | 32,926 | 42,125 |
| " " " 13,123 " " " " | 11,944 | 20,175 | 24,371 | 25,663 | 32,288 |
| Muzzle energy, in foot tons | 50,050 | 62,966 | 74,590 | 71,361 | 88,798 |
| Vertical error at 6,562 yards, in yards | 2.6 | 3.3 | 2.6 | 3.5 | 2.6 |
| " " " 9,842 " " " | 4.4 | 5.5 | 4.2 | 5.6 | 4.2 |
| Accuracy life, in shots | 150 | 240 | 175 | 300 | 200 |

cent. It appears also that at the extreme range of 13,123 yards (the probable limit) the gain in remaining energy is from 100 to 170 per cent with the heavy models of 14-inch and 15-inch guns, and from 70 to 115 per cent with the light models of the same calibers. So if we consider in addition the great increase in weight of explosive carried in the projectile, we appreciate the enormous gain in effect on the target which the last four guns represent. Comparison of the weights of triple turrets of the different models shows an increase of 21 to 57 per cent for the 14-inch and 15-inch over the 12-inch—an increase in weight far below the corresponding gain in fire effect.

It would seem, therefore, in view of the slight differences existing between the heavy model of 14-inch and the light model of 15-inch, that the latter is the gun which should be chosen for the primary armament of our future superdreadnoughts, and that is the example set us by foreign navies. Our present 13.4-inch, model 1911-12, so closely approximates the light 14-inch that the two are almost identical; but it is probable that we shall have to arm our future units with a more powerful caliber—with the light 15-inch, for instance. However, this is a question that is dependent upon the adopted proportion of weight of hull and equipment.—*Le Yacht* (Paris).

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## THE BATTLE CRUISERS *QUEEN MARY* AND *KONGO*

The *Queen Mary* is the product of Palmers shipyard; the *Kongo*, of Vickers Sons and Maxims. Both are derivatives of the *Lion* type, one of the last creations of Sir P. C. Watts. But, while the Palmers yard, constrained to follow official plans, could make only relatively slight improvements in them, on the other hand the Vickers yard, having more latitude, has used to the full extent the experience and practical knowledge of its chief constructor. There has resulted a thoroughly successful type, which will constitute a perfect model for the other three ships of the class (*Hiyei*, *Haruna*, and *Kirishima*) now in construction or about to be laid down in Japanese yards.

In the case of the *Queen Mary*, it should be stated, there were made at the time of its construction modifications as to masts and funnels which were not made in the case of the *Lion* and the *Princess Royal* until after the unsuccessful tests of the first mentioned rapid cruiser. It was thought wise, in the case of the *Queen Mary*, to increase the displacement to 27,000 tons, instead of retaining it at 26,350 as in the case of the *Lion*, the beam being increased from 87.5 feet to 89 feet, the length being retained at 698.5 feet, and the draught retained at 28 feet. In order to keep the speed of 28 knots, it was necessary to increase the power of the *Queen Mary's* engines by 10,000 h.p., making it 80,000 instead of 70,000.

The ship, laid down March 6, 1911, and launched March 20, 1912, has been completed in twenty-four months, which, considering the displacement, is a very good record indeed. Contracted for at 63 million francs, she has, because of the alterations in design, cost 625,000 francs more.

Compared with the Japanese type the *Queen Mary* has the following disadvantages: (1) Inferiority of caliber, both as regards the eight large guns, which are 13.5-inch against 14-inch for the Japanese, and as regards the intermediate armament, which for the English ship consists of sixteen 4-inch guns against sixteen 6-inch for the Japanese. (2) Inferiority of protection, the *Kongo* having all its 6-inch guns in casemates of thickness

varying from 5-inches to 6-inches, while the *Queen Mary* has only shields of 2-inches in thickness to protect its 4-inch guns—a protection that is more than doubtful. (3) Inferiority of belt armor, the *Kongo* carrying plates that vary from 9.8-inches to 6-inches, instead of from 9-inches to 4-inches as in the case of the *Queen Mary*.

| | | Queen Mary | Seydlitz | Kongo |
|---|---|---|---|---|
| Launched | | 1912 | 1912 | 1912 |
| Displacement | | 27,000 | 23,500 | 25,750 |
| Designed H. P. | | 80,000 | 70,000 | 68,000 |
| Speed, designed | | 28 | 27 | 27 |
| Speed, probable | | 34 (?) | 28 | 28 |
| Armament | | 8 13.5-inch<br>16 4-inch | 10 11-inch<br>12 6-inch<br>12 3.5-inch | 8 14-inch<br>16 6-inch |
| Torpedo tubes | | 2 21-inch | 4 20-inch | 8 (?) |
| Armor (inches) | Belt | 9 to 4 | 12 to 7.1 | 9.8 to 6 |
| | Lower deck side | 7 to 5 | 9 | 7 |
| | Turret | 10 to 9 | 9 | 10 |
| | Intermediate guns | 2 | 6 | 6 to 5 |
| | Deck | 3 | 1.5 | 2 |
| Coal | | 900 to 3275 | 900 to 2900 | 900 to 3750 |
| Oil | | 1400 | 190 | 900 |

It is surmised that the Kongo type represents the ideas that have governed in the building of the *Tiger*, the *Queen Mary's* successor, the most recent and possibly the last, of the series of British battle cruisers.

A table is here presented comparing the features of the two types we have been considering and the contemporary German ship *Seydlitz*, which is of the same class.

Let us add, in conclusion, that No. 3 turret of the *Queen Mary* cannot fire in the axis of the ship; on the other hand, owing to a very happy arrangement, the corresponding turret of the *Kongo* fires to the rear over No. 4. It has therefore a much more extensive field of fire.

The *Kongo* presents a better solution of the battle cruiser problem, and has over its British prototypes, from which it is nevertheless clearly derived, the same advantages of armament and protection as those already gained by the *Katori* and the *Koshima* over the *King Edward VII* class, of which they were improved editions.—*Le Yacht* (Paris).

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## KRUPP ILLUMINATING PROJECTILES

Translated from the German by First Lieutenant Nathan Horowitz, Coast Artillery Corps, for the Journal U. S. Artillery

An interesting article in the *Deutsches Offizierblatt** describes a new type of illuminating projectile manufactured by Krupp.

In discussing the relative merits of illuminating projectiles and searchlights for mobile artillery, it points out the fact that, whereas the searchlight

* Furnished for translation through the courtesy of the War College Division of the General Staff.

makes a good target and may be put out of action, it requires less transportation to serve it. To light up a considerable area for an appreciable time with illuminating projectiles would require a great many of these devices, and a corresponding number of caissons to hold them.

The projectile itself is built like a shrapnel, containing a number of layers of flame balls in a black powder matrix separated by thin annular partitions. A black powder fuse runs through the center of the projectile, like a core. The base of the projectile is filled with six "feathers" made of thin metal, which are held in place, folded up against the projectile, when it is fired.

When the projectile reaches the highest point in its trajectory, an automatic arrangement releases the "feathers" at the base, arresting its flight and causing it to float in the air point downwards. At this moment the first layer of flame balls is thrown out. The other layers are thrown out successively, lighting up the field.

## IMPROVEMENTS IN EXPLOSIVES*

In the making up of charges for ammunition according to the practice heretofore adopted, the explosives, such as trinitrotoluol or picric acid, used as igniting charges or exploders for bursting charges, have been of less density than the main charge, in order, on the one hand, to facilitate the transmission of detonation from its source, and on the other hand, to insure as violent a detonation as possible of the igniting charge or exploder. The reason for the adoption of this practice, which is still in vogue, is that the main charge (such as trinitrotoluol or picric acid) when compressed to its highest practicable density will not develop its maximum power with the means of initial impulse hitherto used, unless such a charge of less density be interposed between the main charge and the means of initial impulse. It is evident that a column of explosive of less than the highest density, when subjected to great firing strain, is liable to be compressed until its maximum density is reached. Such compression, however, involves a movement of the explosive in the casing accompained by considerable friction which might easily cause ignition of the explosive. The inventors have by experiment ascertained that sensitive highly shattering explosives, as for instance tetranitromethylanine, tetranitroaniline and lead azide, when they are compressed to their highest density, retain their property of facility to detonate by means of the initial impulse of fulminate of mercury and like substances, notwithstanding their maximum compression, to such a degree that complete detonation of the compressed charge is secured without any difficulty. The property of facility to detonate by means of the initial impulse of fulminate of mercury is accompanied in compressed charges of highest density consisting of the said explosives by two other exceedingly valuable properties, viz., that of greatly increased safety against premature ignition under great firing strain and a very considerable increase of detonating power. By this invention the following advantages are claimed:—Certain detonation by initial impulse even when the density is a maximum; increased safety against premature ignition under high firing strain; greater shattering power and strength;

* British patent No. 2407, 30th January, 1912. Dynamit-Actien-Gesellschaft, vormals Alfred Nobel & Co., Europa Haus, Alsterdamm 39, Hamburg, Germany.

improved transmission of detonation to large charges of sluggish explosives. By using igniters and igniting charges made of the said materials compressed to the highest practicable density enables the inventors to dispense entirely with the intermediate charge hitherto used in trinitrotoluol shell charges. In this way the manufacture of such charges is simplified.

—*The Broad Arrow.**

# NOTICES

## BUREAU OF MINES' PUBLICATIONS FOR FREE DISTRIBUTION

DEPARTMENT OF THE INTERIOR

BUREAU OF MINES

New Publications.

(List 19.—May, 1913.)

*Technical Papers*

Technical Paper 52. Permissible explosives tested prior to March, 1913, by Clarence Hall. 1913. 11 pp.

(List 20.—July, 1913.)

*Bulletins*

Bulletin 51. The analysis of black powder and dynamite, by W. O. Snelling and C. G. Storm. 1913. 80 pp., 5 pls., 5 figs.

*Technical Papers*

Technical Paper 37. Use of heavy oils in internal-combustion engines, by I. C. Allen. 1913. 36 pp.

Technical Paper 49. The flash point of oils, methods and apparatus for its determination, by I. C. Allen and A. S. Crossfield. 1913. 15 pp., 2 figs.

The Bureau of Mines has copies of these publications for free distribution, but can not give more than one copy of the same bulletin to one person. Requests for all papers can not be granted without satisfactory reason. In asking for publications, please order them by number and title. Applications should be addressed to the Director of the Bureau of Mines, Washington, D. C.

## CHICAGO PNEUMATIC TOOL COMPANY

The Chicago Pneumatic Tool Company's Compressor Department Bulletin 34-L, is one of a series covering their complete compressor line, and treats particularly of general engineering information of value to users of compressed air. It contains tables giving efficiencies of air compression at different altitudes, density of gases and vapors, mean effective pressures and horse powers, loss of pressure due to friction in pipes, and many other tables.

This bulletin is sent gratis to those interested, upon application to the Chicago Pneumatic Tool Co., Fisher Building, Chicago, or No. 50 Church St., New York City, or any of its branches in all large cities.

* Furnished for publication through the courtesy of the War College Division of the General Staff.

# BOOK REVIEWS

**A History of Cavalry. From the Earliest Times. With Lessons for the Future.** By Colonel George T. Denison, late commanding the Governor-General's Body-Guard, Canada. New York: The Macmillan Co., 66 Fifth Ave. 6¼"x9". xxxi+468 pp. 11 maps and plans. 1913. Price, $2.75 net.

This work was first issued in 1877, and the present edition (1913) is a reprint with an additional preface in which the author briefly refers to the employment of cavalry in the Boar War of 1899-02 and the more recent Russo-Japanese War.

The author is well known as an experienced and able writer on cavalry subjects, his history of cavalry having been awarded a prize of 5000 rubles by the Emperor of Russia for being the best history of cavalry.

This book contains eleven maps and plans. Over two hundred battles and skirmishes are discussed in which cavalry played an important, and in many cases a decisive, part.

The history begins with the earliest use of the horse for war purposes, when chariots were used to convey warriors into action, and traces the rise of the cavalry service down to the present day.

The author fully discusses the effect of events in the world's history which have had their influence on the methods of employment, the organization, the armament, and the equipment of cavalry, and does not fail to note, to quote his own words, "the peculiar way in which ideas have arisen and have been carried to excess, and how opinions have swayed at one time in favor of cavalry, at another time in favor of infantry, and how often these opinions have been carried to extremes."

In the concluding chapters of the work the author sums up his opinions on the organization, armament, and employment of cavalry in modern warfare, from the experiences of the past drawing certain lessons for the future.

His opinions will appeal to our own service as being sound; in fact, many of the author's conclusions in regard to the proper armament and employment of cavalry are supported by instances drawn from the brilliant exploits of the cavalry leaders of our civil war.

The use of the book as a work of reference is greatly facilitated by a complete index and a table of contents.

✦ ✦ ✦

**Jackson's Campaigns in Virginia, 1861-2.** By Thomas Miller Maguire, M. A., LL. D., F. R. H. S. London: William Clowes and Sons, Limited, 23, Cockspur St., S. W. 5½"x8½". 62 pp. 6 maps. Cloth. 1913.

This little book has been written to meet the demands for a treatise which will assist officers of the British Army in their preparation for examinations for promotion. Strong criticism is made of the British policy under which certain periods or events of military history are assigned each year for

promotion examinations and the book closes with directions to candidates on "The Tactics of the Examination Hall," which are rather startling in their simplicity.

The author endeavors, and quite ably, to impress the fact that Jackson's campaigns should not be studied as a unit, but as one part of the great Civil War; and therefore he gives a brief summary of events leading up to these operations in an effort to show that they were but a part of the strategy of the whole war.

The description of each battle of any note is concise, and collectively the descriptions give of Jackson's superb strategy an excellent general idea; though the *analysis* of his strategy which the book contains would appear to be of value only when used in connection with a more comprehensive work. As is so often the case, many places are mentioned which cannot be found on the small maps accompanying the text.

The following statement is made: "The Southern President, Jefferson Davis, was a soldier himself, and as such, had the good sense not to interfere with his Generals engaged with the enemy, while the Northern President and Secretary of State for War, as is well known, simply courted disaster by constant interference." However this may be, it is a well established fact that the Southern President, Jefferson Davis, allowed his personal animosities to sway him; and he transferred or relieved officers, over the protest of Lee, for purely personal reasons, which resulted in many cases in great damage to the Southern cause.

The little volume evidently answers the purpose for which it was written, i.e., to enable officers to study up the subject assigned for the year and to pass the necessary examinations.

✤ ✤ ✤

**The Russo-Japanese War. (The Campaign in Manchuria, 1904 to 1905.)** Second Period—The Decisive Battles. By Captain F. R. Sedgwick, Royal Field Artillery. New York: The Macmillan Company, 66 Fifth Ave. 5½" x 7½". 347 pages. 21 maps in pockets. Cloth. 1912. Price, $3.50 net.

This book is the second volume of Captain Segdwick's work, *The Russo-Japanese War*, and the sixteenth volume of the well known "*Special Campaign*" *Series*. It treats of the two great battles of Liaoyang and the Shaho, which the author correctly describes as the decisive battles of the war.

The British Official Account and the reports of British officers are cited as the authorities for the work, although there is plenty of evidence that in his study of the campaign, the author's research has been painstaking and extensive.

The story of the campaign is told in a clear and straightforward manner, with sufficient detail to enable the reader to perceive the relation of events as they occur; and the pleasure derived from its study is increased by the following features: good maps in pockets; British official spelling; a simple system of indicating the strength and composition of detachments; and cut-in heads in bold-face type. Another feature that facilitates study is found in the brief synopsis of each battle which precedes the detailed account of it, a feature which is greatly to be commended, as the significance of the events described in the detailed study is more readily understood, when the rough outline of the entire action has already been presented.

The author divides the battle of Liaoyang into five phases as follows:

1. Russians forced to withdraw to their prepared position.
2. Main attack on Russian prepared position, and turning movement by Japanese right begun.
3. Withdrawal to Liaoyang and concentration against Japanese left. Capture of Manjuyama by the Japanese.
4. Repulse of the Japanese at Liaoyang and the failure of the Russian counter-stroke.
5. The Russian retreat.

The Battle of the Shaho also is divided into five phases:

1. The armies come into close contact.
2. The Russian eastern group attacks, and the Japanese assume the offensive and advance.
3. The Japanese hold the attacking eastern group and force back the center and western groups.
4. The Russian retreat across the Shaho.
5. The failure of the Russian counter-stroke.

The actions of both armies for these phases are then described in detail, and the reasons for failure and success clearly indicated.

The book closes with a chapter of comments on the conduct of the campaign and the lessons to be learned, which is most instructive and valuable.

The press work is excellent and the book is fairly well bound in yellow cloth.

✤ ✤ ✤

**With the Bulgarian Staff.** By Noel Buxton, M.P. New York: The Macmillan Company, 66 Fifth Avenue. 5¼" x 7¾". xvi+165 pp. 22 il. 1913. Price, $1.25 net.

This work does not, as its name would imply, deal with the work of the Bulgarian Staff. It is a narrative detailing what the author saw following in rear of the army.

The political situation in the Balkans before the war and the wrongs that caused it are discussed. The Bulgarian character and education are given as the cause of Bulgarian success.

The care of the wounded is the principal military feature of the work. The suffering of the wounded, and the cruelties inflicted on them and on the noncombatants by the Turks, are vividly related.

It is not a military work, but gives a realistic view of the gloomy side of war.

✤ ✤ ✤

**Amendments and Additions to Modern Guns and Gunnery.** To March 1, 1913. By Colonel H. A. Bethell, late R. F. Artillery. Woolwich, England: F. J. Cattermole, Wellington St. 6" x 10". 10 pp. 1913. Price, 6d.

Of the amendments there are ten pages, printed on one side only and arranged and spaced for convenient cutting, in order that they may be inserted in the text at the pages indicated. Altogether there are eighty-one.

They comprise corrections of typographical errors as well as additions made in the light of the Balkan war, and they range in length from four words to almost a page. They contain interesting items of information relative to all departments of modern guns and gunnery: methods of control; sights; projectiles; fuzes; explosives; aviation; etc.

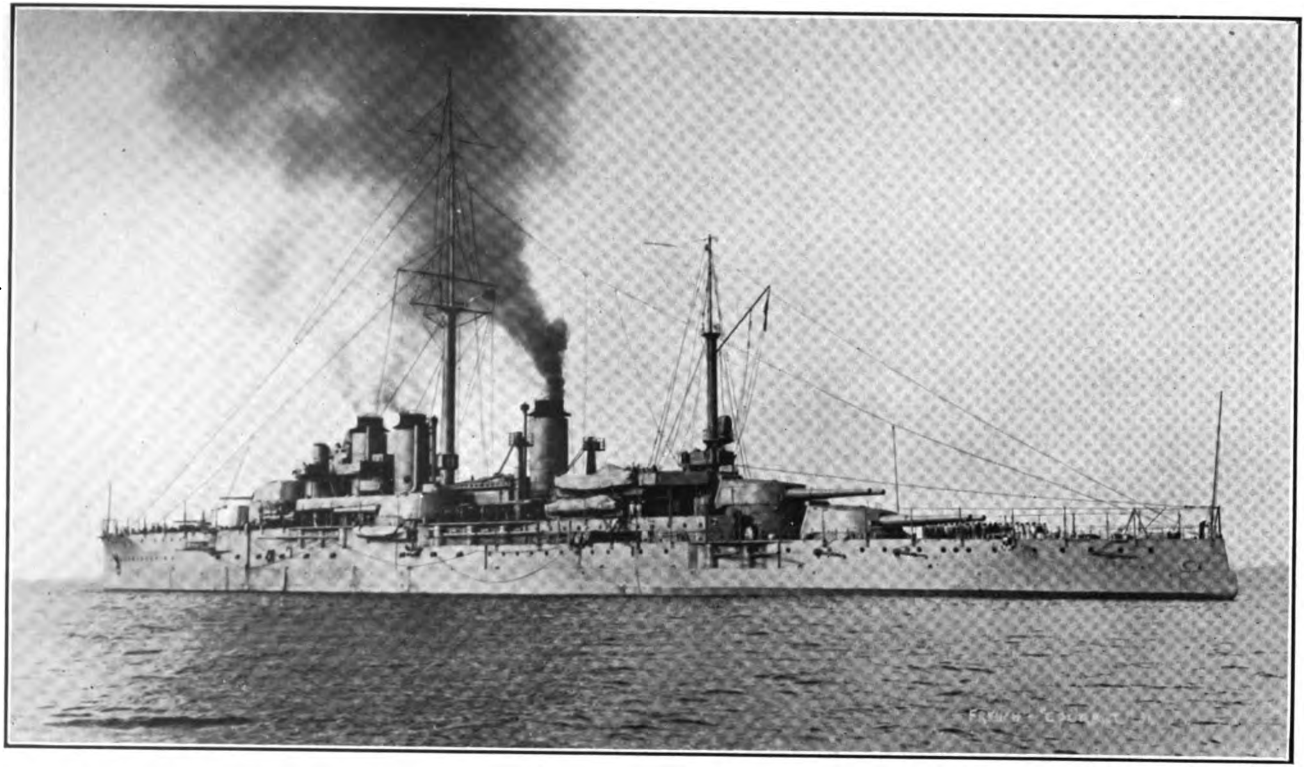
The "Amendments and Additions" make of "Modern Guns and Gunnery" a thoroughly up-to-date manual of its subject.

✤ ✤ ✤

**Supplement No. 1. Manual for Army Cooks.** By Captain C. A. Bach, Quartermaster Corps, U. S. Army, in charge of the School for Bakers and Cooks, Fort Riley, Kansas. Fort Riley, Kansas: Mounted Service School. 4½"x6½". 110 pages. 14 il. 1912. Cloth. Official Publication.

This book gives much information relative to meats, fish, and vegetables, as well as many valuable recipes for meats, fish, vegetables, salads, breads, and desserts, all of which are valuable and practicable for the company mess and not found in the Manual. The supplement contains also many useful suggestions as to the management of the kitchen, as to cooking in camp and on the march, and as to the care of provisions in the field. It is thoroughly practical and should be studied by every company commander, mess sergeant, and cook. It is nicely printed on good paper, suitably bound and well indexed.

*Frontispiece.*



*Photograph by Stephen Cribb, Southsea.*

1312

THE FRENCH BATTLESHIP COURBET

(See page 249.)

# JOURNAL

OF THE

# UNITED STATES ARTILLERY

*"La guerre est un métier pour les ignorans
et une Science pour les habiles gens."*

VOL. 40 No. 2 SEPTEMBER—OCTOBER, 1913 WHOLE No. 123

## GUNS, AMMUNITION, AND ACCESSORIES*

BY MAJOR EDWARD P. O'HERN, ORDNANCE DEPARTMENT

### EXTREME RANGES

With a view to increasing the extreme ranges, a 700-lb. projectile has been adopted for use in certain batteries of 12-inch mortars. Some of these projectiles have been completed and issued to fortifications and additional ones are under manufacture. With this projectile a maximum range of approximately 15,000 yards is obtained as compared with approximately 12,000 yards previously obtained with the 824-lb. projectile. The new projectile is of the long pointed type, as the muzzle velocity was sufficiently high to make the use of such a point materially increase the maximum range. Its bursting charge is approximately 24 lbs. of explosive "D." The prescribed acceptance test requires that the projectiles shall be in condition for effective bursting after having completely perforated three inches of special treatment steel of the quality furnished on current orders for deck plates for battleships. A striking velocity of 950 f.s. and an angle of incidence of 55 degrees measured from the face of the plate, are prescribed for the tests, those being the most severe conditions likely to be encountered in the service use of these projectiles.

For use in the Isthmian Canal defenses a 12-inch mortar has been designed which is five calibers longer and which has

* A lecture delivered before the student officers in the Department of Artillery and Land Defense of the Coast Artillery School, April 4, 1913.

a slightly larger chamber than the previous models. In Fig. 1 is shown the relative size of this mortar and the previous model. The longer mortar will have a muzzle velocity of 1850 f.s. with the 700-lb. projectile, this being an increase of 350 f.s. This should give a maximum range of about 20,000 yards, or slightly more than eleven miles.

In view of the tendency towards the use of longer ranges in naval firings and of the apprehension that is apparently felt by some coast artillery officers that the land service can not meet

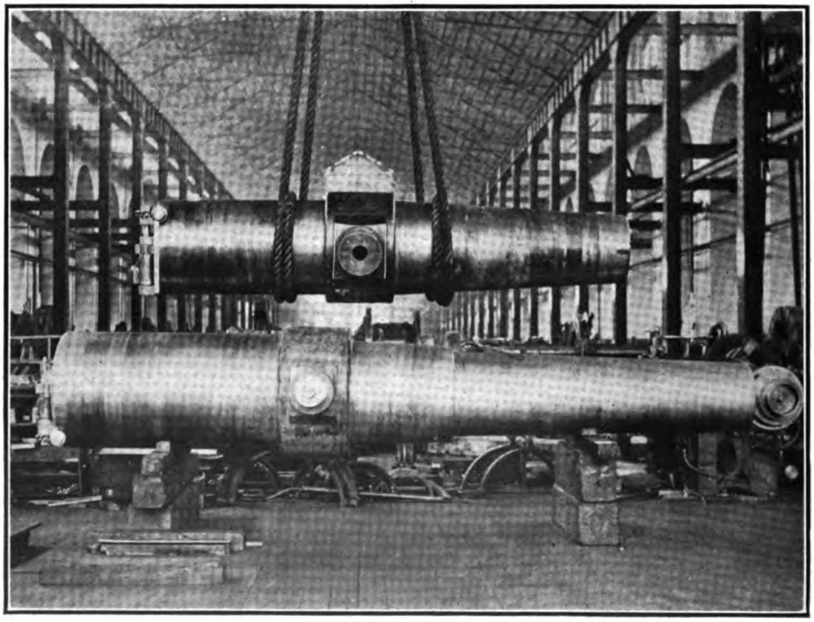


FIG. 1. 1313

such fire, it may be stated that the extreme ranges of the service guns and mortars can, through the adoption of sufficiently light projectiles for use at the longer ranges, be increased to practically any extent considered desirable. Such projectiles would be inferior to the present service types in having less strength for armor penetration or in carrying a less weight of bursting charge, with probably a combination of these disadvantages. Computations indicate that, by using an 800-lb. projectile, a muzzle velocity of approximately 2600 f.s. can be secured in the existing 12-inch guns. A range of approximately 16,000 yards could thereby be obtained at 10° elevation,

in place of the range of 13,186 yards now obtained with the 1070-lb. projectile at 2250 f.s. muzzle velocity. With the 700 lb. projectiles which are being supplied to 12-inch mortars at fortifications where ranges beyond approximately 12,000 yards are desirable, a maximum range of approximately 17,000 yards could be secured with the service 12-inch guns. It appears to me probable that some lighter weight projectiles will be eventually furnished for the 12-inch guns; but this is not likely to happen in the near future, in view of the fact that there is now on hand slightly more than one hundred per cent of the prescribed allowance of standard projectiles for all guns of that caliber mounted.

The necessity for increasing the maximum range of the 12-inch guns beyond the 13,186 yards now secured, is not believed to be urgent, since the target presented by them, especially by those mounted on disappearing carriages, as most of them are, is so small and so indistinct that a fleet could not hope to carry sufficient ammunition to do a battery serious injury. This view is supported by the little damage done to the guns and mounts by the bombardment to which the defenses of San Juan, Porto Rico, and Santiago, Cuba, were subjected during the late war with Spain. These bombardments were, moreover, chiefly at considerably less than one half the range under consideration.

Another point of importance in this connection is that 12-inch guns are almost invariably accompained by 12-inch mortars, which, with the 700 lb. projectile being supplied, will have a maximum range of approximately 15,000 yards. This will usually serve to keep the attacking ships from coming within that range of the direct fire guns almost as well as if those guns had themselves that extreme range.

### ARMOR PENETRATION

Armor penetration as a function of the range for the service guns of various calibers with long pointed projectiles at normal impact, is shown in Fig. 2.

It will be noted that the 16-inch gun to be mounted in the defenses of the Panama Canal has a maximum range of approximately 18,500 yards and an approximate penetration of 12 inches in K.C. armor at that range. The corresponding limits for the 14-inch 2250 f.s. gun are 18,000 yards and 9.5 inches of armor.

Attention is invited to the fact that the armor penetration

curve for the Army 14-inch 2250 f.s. gun crosses that of the Navy 14-inch 2600 f.s. gun at 14,000 yards. It is commonly known that the strength of the projectile, especially on oblique impact, is of primary importance in determining armor penetration. The 260 lbs. additional weight in the Army 14-inch projectile permits the use of a stronger shot and the use of a large capacity shell. The high velocity, light projectile gun has no equivalent projectile for the latter. It will be seen that the Army 14-inch 2250 f.s. gun gives sufficient striking velocity

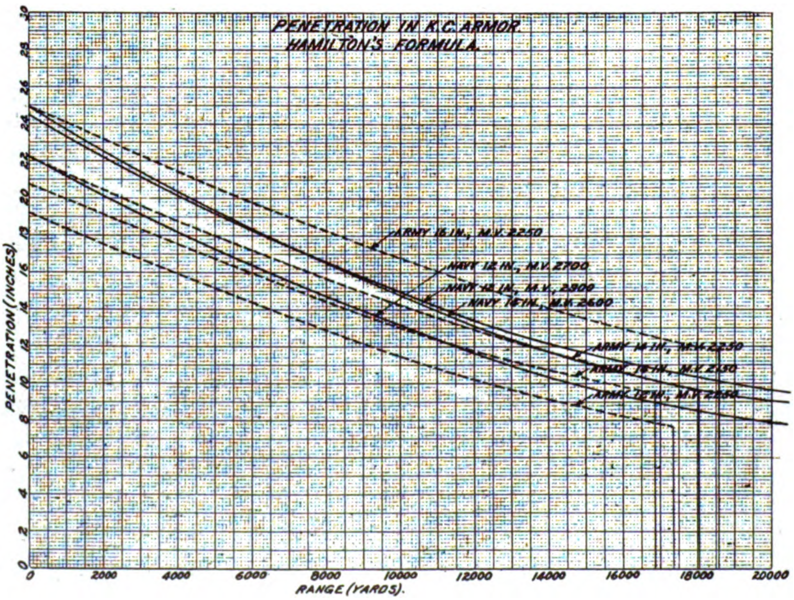



FIG. 2. 1314

to perforate 12 inches of K.C. armor up to 13,500 yards and to perforate 9.5 inches at the extreme range of 18,000 yards. These perforations will apparently meet all practical needs.

The Army 12-inch, 2250 f.s. gun will perforate 12 inches of armor at normal impact up to 9500 yards and will perforate 7.75 inches at the extreme range of 17,500 yards.

### ACCURACY LIFE OF GUNS

The Department has obtained no additional data on the accuracy life of guns which materially alter the conclusions published in the appendix to the Report of the Chief of Ordnance for 1906, specifying the accuracy life of guns as a function of the caliber, muzzle velocity, etc. The later adoption

of broad bands for projectiles has undoubtedly greatly increased the accuracy life, possibly doubled it, but the exact extent has not yet been ascertained. Other changes have also been made with a view to increasing the accuracy life. Thus the depth of the rifling has been increased, the number of lands increased, and the forcing cones modified.

Fig. 3 shows changes made in the forcing cones. Guns manufactured prior to about 1905 had forcing cones about four calibers long and had only the lands tapered, the depth of the rifling at the beginning being one-half the normal. The

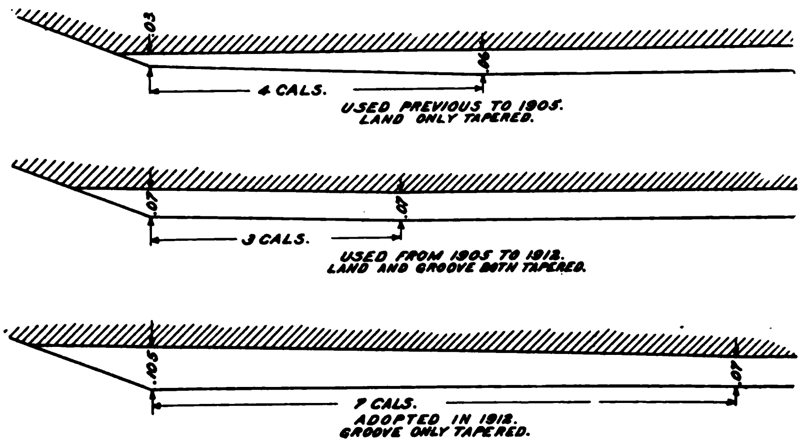



FIG. 3. 1315

Variations in forcing cones of guns. Dimensions given apply to 12-inch guns

number of grooves was six per inch of diameter. About 1905 the forcing cone was shortened to about three calibers and the grooves given the same taper as the lands, making the lands of uniform height over their entire length. The number of lands was increased from 6 to 9 per inch of diameter at the same time, thus increasing the bearing area of the band fifty per cent and consequently extending the time before the projectile would fail to receive its full rotation. Bands one-third of the caliber in width were later adopted in place of the earlier type which were only one-eighth of the caliber in width.

During 1912 a further change was made in the forcing cone by tapering the grooves only and by having the taper extend farther forward to seven calibers. The rifling at the beginning, where the greatest erosion occurs, is now one and a

half times the normal depth, and reaches the normal depth seven calibers forward, where the erosion has been found to be practically nil. This arrangement retains whatever advantage there may be to the forcing of the band, and at the same time provides an increased depth of rifling over that portion of the bore where erosion is sufficiently serious to affect the accuracy life. It is not certain that this change can be fully incorporated in all models, since it may interfere to some extent with the ease of ramming the projectile. That point is to be determined by a loading test on the first one of each type modified. It is unsafe to predict just how much the accuracy life will be increased by these changes, but there is little doubt that the effect will be very material.

With the adoption of the broad banded projectile there was a tendency towards adopting a uniform-twist rifling, due to the great deformation which a variable twist produces in the broad band. The uniform twist was adopted by the Navy Department but was soon abandoned, as it was found to diminish greatly the accuracy life. The difficulty with uniform-twist rifling is that the maximum pressure on the lands is near the beginning of the rifling, where the greatest erosion occurs. Therefore, when the rifling is worn, the band is more apt to shear than when the increasing twist is used. The maximum pressure on the lands with the increasing twist is nearly as high as with the uniform twist, but it occurs farther down the bore where there is little erosion.

Various devices have been tested with a view to reducing erosion. Among these devices are: increased width of lands, which was supposed to reduce the temperature to which they would be heated by the gases; decreased diameter of chamber, in order that there should be less throttling of the gases where they enter the bore proper; and the use of a fiber gas-checking disk on the rear end of the projectile. The latter test is still in progress, but none of the devices gives promise of having any appreciable effect upon erosion. A smokeless powder that burned at a lower temperature would undoubtedly be efficient, just as nitrocellulose powder produces decidedly less erosion than nitroglycerin powder does. There, is, however, no present prospect of producing a powder with a lower temperature of combustion than that of nitrocellulose.

Numerous erosion tests have been made at Springfield Armory within the past two years, using barrels of various grades of steel. In these tests, in order to save ammunition,

very erosive powder (nitroglycerin) was used, and the firings conducted as rapidly as possible. These tests indicated that the service gun steel is quite resistant to erosion; but that vanadium steel and an imported cast steel, were slightly superior to the usual gun steel, while the latter was decidedly superior to nickel steel. Various other steels were found still less efficient. These tests indicated considerable variation in the erosive qualities of various grades of steel, the grades showing the least erosion usually being those that had the highest melting points. Further tests are now under way with gun steel and nickel steel in comparison with a few steels of such compositions as are especially refractory while possessing promising physical qualities. The melting points of these steels are being determined by the Bureau of Standards. Not much hope can, however, be held out for material improvements in large caliber guns along this line. Even if a special steel with high melting point is produced, it is improbable that it will be of suitable physical properties for large gun tube forgings. While the vanadium steel is especially promising, the present status of the manufacture of that steel is not such that large forgings of uniform qualities can be produced.

### 14-INCH GUNS

The 14-inch gun was advocated by the Ordnance Department and the first type laid down with the idea of providing a weapon that would take the place of the 12-inch 2500 f.s. gun, the latter having demonstrated that its accuracy life was hardly equal to a single engagement. A gun of that power was at the time considered as being more than a match for the armor being installed, and there was no apparent need for the more powerful 14-inch guns later developed to meet the increased thickness and other improvements in the quality of armor.

The length of the gun (34 calibers) was limited so that it could, if found desirable, be used in emplacements already provided for 12-inch guns. The muzzle velocity was established at 2150 f.s. to secure a penetration in K.C. armor at 8000 yards approximately equal to that of the 12-inch, 2500 f.s. gun, while securing an accuracy life which has proved to be approximately four times as long. While the danger space is somewhat less than that of the 12-inch, 2500 f.s. gun, the striking energy is materially greater at all ranges, and the bursting charge is approximately fifty per cent greater. The

results of target practice with other calibers indicate that this gun has sufficient danger space to insure a satisfactory percentage of hits. The great weight of the projectile, 1660 lbs., as compared with a weight of 1400 lbs. in other services, permits the use of a very strong A.P. shot and of a large capacity A.P. shell.

In the 14-inch guns radical departures were made, both in the construction of the gun and in the breech mechanism. This applies to the built up type as well as to the wire-wrapped type. In order to reduce the weight of the breech mechanism,

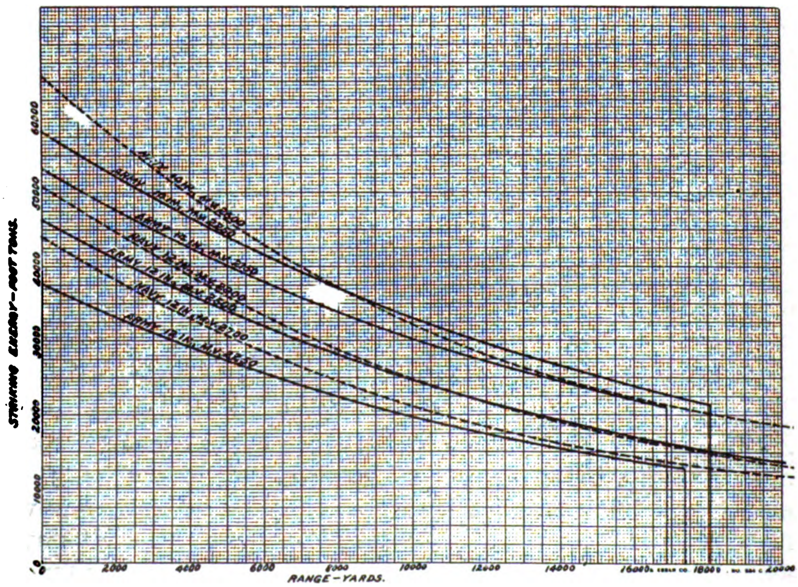



FIG. 4. 1316

and thus increase the rapidity of opening and closing, the breech block was made of very high grade material (E.L. 75,000, T.S. 110,000) and the Welin, or step, block was used. The principal reason for the large size of the breech blocks previously used was the necessity for obtaining sufficient thread area. In the 14-inch the use of higher grade material permitted a reduction in the total thread area; while the use of the Welin thread permitted a further reduction in the dimensions of the block, since it made only one blank sector necessary for each three threaded sectors, instead of a blank for each threaded one. In order to obtain the full benefit of the high grade material in the breech blocks, it was necessary that the threads

should bear in material of the same grade. For this reason a breech bushing was used, instead of having the breech block seat directly in the jacket, as was previously the case.

By means of these improvements the breech mechanism of the 14-inch gun, though required to withstand a much higher total pressure than that of the 12-inch gun, could be made approximately sixteen per cent lighter than that of the 12-inch Model 1888.

In reference to the tendency to condemn the early 14-inch type as being inferior to the later ones, it should be remembered that it was a world pioneer in its class, it being laid down at a time when 14-inch guns were not generally considered necessary. Four of the 34-caliber guns were manufactured for the service and one for use at the Proving Ground.

The manufacture of the four 14-inch guns of the built up type was undertaken simultaneously with that of the first of the wire-wrapped type, because the Department did not feel justified in inaugurating the manufacture of so many large caliber wire-wrapped guns prior to the completion and test of the type gun, and the manufacture of the four guns needed for the fortifications could not be delayed to await that test.

The necessity for a more powerful gun soon became apparent, as our Navy and foreign navies began developing guns of that caliber. A new type, the Model 1909, 40 calibers long, six calibers longer than the previous models, was accordingly designed. The following year when money became available for the manufacture of guns for use on disappearing carriages, a trunnioned gun of corresponding length, was laid down. This is known as the Model 1910. The 14-inch guns to be installed in the fortifications at San Pedro harbor, work on which is about to commence, will be of this type.

Both the 34-caliber and the 40-caliber 14-inch guns have the same chamber capacity, so that the powder charges are practically interchangeable. The charge which gives a muzzle velocity of 2150 f.s. in the short gun gives a muzzle velocity of 2250 f.s. in the long gun, an increase of approximately 17 f.s. per caliber.

The striking energy and armor penetration of the 40-caliber gun at battle ranges compares favorably with that of the most powerful gun in use elsewhere, while its accuracy life is believed to be twice as great. Gun No. 1 (34 calibers) has been fired approximately 123 rounds to date. The con-

dition of the bore is such that it can safely be predicted that the accuracy life will probably reach 300 rounds or more. The accuracy life of the 40-caliber gun is expected to be only slightly less, since the only factor tending to increase the erosion is that the projectile is in the bore about .003 second longer.

The 14-inch guns, model 1909 and 1910, are constructed with double tubes. This construction was adopted in view of the prevalence of heat cracks which are liable to extend so deep as to make a single-tube gun unsafe and unsuitable for relining. With the double tubes any heat cracks that develop will probably be confined to the inner, or lining, tube. The strength of the gun is such that it would be safe to fire even if the lining tube were split the whole length. In case of emergency the gun could, therefore, be used through an engagement in this condition and would be suitable for relining afterwards. This construction also facilitates the operation of relining. The Department has in one case (the only one tried) succeeded in dropping out a liner of this construction by simply heating the gun to a moderate temperature, then turning cold water through the bore.

### EFFICIENCY OF SERVICE GUNS

In reference to the feeling on the part of some coast artillery officers that the service low velocity guns using heavy projectiles are inferior to high velocity guns using light weight projectiles, it may be pointed out that the apparent superiority of the high velocity guns consists chiefly in their flatter trajectory, since, as indicated by the curves shown in Fig. 2, they have theoretically little greater armor penetrating power at fighting ranges. On account of the greater strength of the heavy projectile of the low velocity gun, it is thought probable that more of them would get through the armor at every range. In any event, the high velocity guns have insufficient penetrating power or projectile strength to perforate the shields of the turret mounts being constructed for use at El Fraile, or presumably the sand and concrete parapets of the seacoast fortifications. There is little doubt but that the naval guns are well suited for their chief work, the attack of ships, and that they need a flat trajectory in order to make a reasonable percentage of hits under the severe conditions of both a moving gun platform and a moving target. They have the serious disadvantage of a light weight projectile and of an extremely

short accuracy life, but the latter is partly offset by the ease with which worn guns can be removed and replaced by taking the ship to a navy yard.

The time and expense of dismounting a land defense gun and of returning it to Watervliet Arsenal for relining, especially from our insular possessions, are matters of serious importance. The target practice records of the Coast Artillery indicate that a satisfactory percentage of hits can be secured with the danger space of the service guns; so why should the accuracy life, the amount of bursting charge, or the strength of projectile be sacrificed in order to secure a higher velocity or a flatter trajectory? The price to be paid for securing the advantages of a flatter trajectory is evident from the fact that the Navy Department has requested an appropriation of $125,000 for the current year for the work of relining guns. It was stated in the hearings that this would be a continuing appropriation from year to year.

### POWDER BAGS

More or less difficulty having developed in loading the short powder sections of large diameter used in 12-inch and 14-inch guns, tests were inaugurated to improve the bag so as to make the sections more rigid and thus to prevent jamming. The use of a cord running centrally through the section and fastened to each end, thereby maintaining the section of a fixed length, proved quite satisfactory. Tests are, however, now in progress with what appears to be a more satisfactory device, consisting of a small central tube, or core, of powder bag material fastened to the ends. This core contains about one-third of the priming charge, the powder forming practically a solid cylinder. It is thought that this distribution of the priming, by providing a column of black powder through the center of the charge, will give a more rapid and uniform transmission of ignition than that heretofore obtained. This is expected to result in increased uniformity of velocities and pressures. To further stiffen the powder sections, a number of circumferential bands of the powder bag material have been added with a view to reducing the amount of stretch arising during the storage and handling of the charge. For 12-inch and 14-inch gun charges three bands, each about one inch wide, are used. Bags of the new type are being used in current firings at the Proving Ground in order to determine whether unconsumed fragments of cartridge bag material are likely to

remain in the bore from the use of the greater number of thicknesses of cloth.

### POWDER LOADING TRAY FOR 12-INCH AND 14-INCH GUNS

With a view to further reducing the liability of the jamming of the powder section, tests have been made at the Proving Ground and are being continued at Fort Hancock with a powder loading tray for 12-inch and 14-inch guns. It is of the general character of the one suggested by Captain Dengler, C. A. C., as described and illustrated in the January-February number of the JOURNAL except that the one developed at the Proving Ground is designed to carry an entire powder charge instead of two sections only. This tray is in the form of a trough and is carried by four men. The entire charge is placed on the tray and rammed as one unit. The shape of the tray keeps the sections in alignment. The use of such a tray is expected to increase the rate of fire by preventing jamming of the powder sections during ramming. It has a further advantage in making it unnecessary to keep the gun at a fixed azimuth during the ramming of the powder charge.

### HAND LOADING TRAY FOR RAPID FIRE GUNS

Due to the injury sustained by gas check seats in rapid fire guns, a hand loading tray in the form of a hollow cylinder of the general shape of the breech recess has been provided, and is to be issued for all 5-inch and 6-inch R. F. guns.

A man standing at the left of the breech of the gun handles the tray by means of a long handle projecting from one side. The projectile and charge are loaded through the tray, which has been found to protect the gas-check seat effectively without materially reducing the rapidity of loading. The use of the tray requires, however, an extra man in the gun detail. It has been found necessary to ream out the gas check seats of a number of R. F. guns in service in order to remedy the damage arising from blows from projectiles in loading.

### SMOKELESS POWDER: BLENDING, ABSORPTION OF MOISTURE, ETC.

Since the Board of Officers consisting of Colonel Babbitt, Ordnance Department, and Major Hamilton and Captain Bishop, Coast Artillery Corps, convened for the purpose of making a study of all features of guns, carriages, and ammunition, with the object of determining their probable effect upon the accuracy of fire, reported that their investigations indicated

that the powder was the greatest source of error, the Department has been gathering data with a view to determining and eliminating possible troubles of that character. The first point considered was improvement in blending. For this purpose, two lots of 12-inch powder, one of which contained rosaniline, thus making its identification possible, were put through the blending tower four times, the efficiency of the blending being ascertained after each run through. The results showed that the mean error of blending was reduced as the number of blends was increased, but that the maximum error (the error in a particular box) was greatest after the last blend. The data was submitted to the Joint Army and Navy Board on Smokeless Powder, which stated that it seems probable that the greater time of exposure required for the repeated blending more than counteracts the good results arising from the better blending. The tests indicated that the usual blending is reasonably thorough.

Investigations were also undertaken to determine the effects upon the ballistics of storage of powder at fortifications. For that purpose a number of charges of the oldest lots of powder in service were returned to Sandy Hook from the artillery districts of Portland, Me., and Pensacola, Fla. Those longest on hand and stored in the most unfavorable magazines were asked for. Those turned in were, therefore, among the worst in the service. Their moisture and volatiles were determined and the charges subsequently fired.

Eight of the eleven lots tested gave muzzle velocities closely in accord with the prescribed service velocity. Three of the lots gave low muzzle velocities. One of these was manufactured in 1900, one in 1901, and one in 1905, all being, therefore, fairly old. The pressures obtained with all these lots were such that the charge could be modified to secure service velocities without objectionable pressures. The results, on the whole, were considered very satisfactory. Fig. 5, showing the change in muzzle velocity as a function of the change in moisture and volatiles, fails to indicate any connection between these factors in as far as concerns these firings. Evidently, other elements not yet determined entered into the results. No tests thus far made have indicated any definite law connecting muzzle velocities with age or with storage conditions.

The rate at which powder will absorb moisture has been directly investigated. The results obtained to date are plot-

ted in Fig. 6. In these tests the powders were exposed to a *saturated* atmosphere. Firings were made with the 3-inch field gun to determine the change in muzzle velocity to be expected for a given increase in moisture and volatiles. The results as plotted are shown in Fig. 7. The results of the two sets of firings made were fairly consistent. In one set, the powder was dried in the ordinary manner and the charges then exposed to a saturated atmosphere for different periods of time until they had absorbed the desired percentages of moisture. In the other set, the powder was withdrawn from a new lot at various stages of the drying operation.

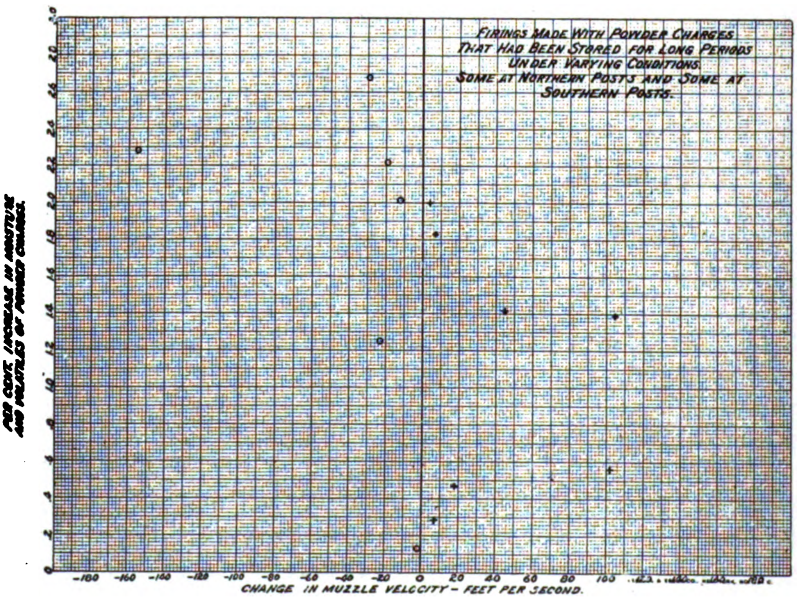



FIG. 5. 1317

For both sets of firings it was found that an increase of about one per cent in moisture and volatiles gave a reduction in velocity of about 100 f.s. In view of the fact that powder exposed to a *saturated* atmosphere will receive from absorption or condensation on its surface, one per cent of moisture in from one to three days, it is important that it be not exposed longer than necessary during the blending operation, and that the work be done when the weather is favorable. In fact, it seems a fit subject for consideration, whether the evil effects of the exposure does not more than offset the improvement due to

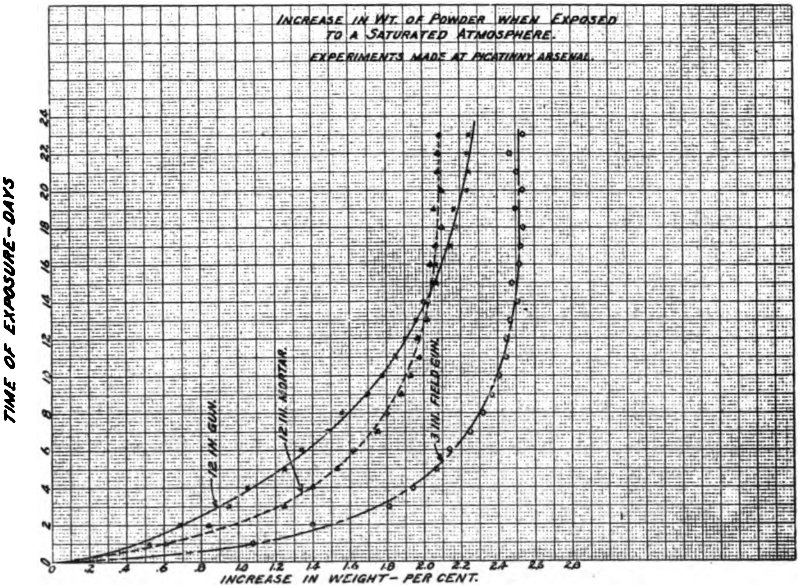



FIG. 6. 1318

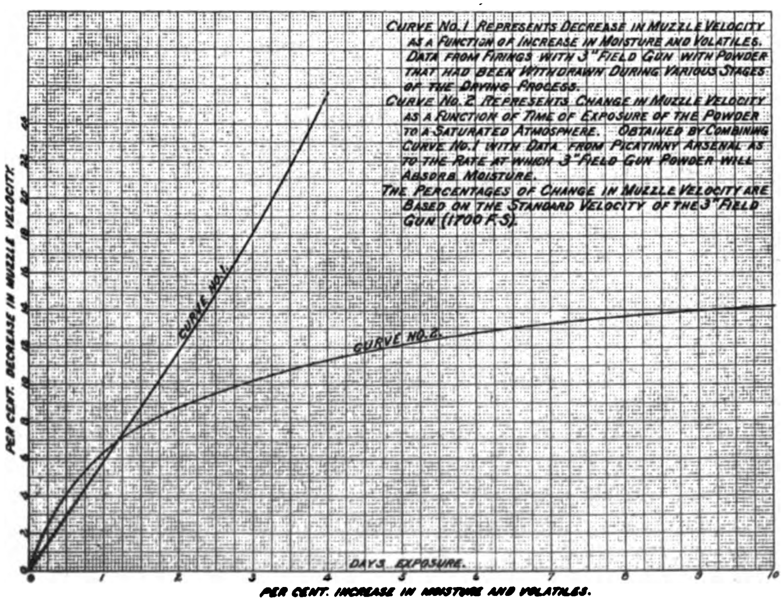



FIG. 7. 1319

blending. It would evidently be difficult to obtain conclusive data on that point.

Tests are in progress to determine the amount of moisture that is absorbed during the blending operation as carried on at seacoast fortifications. Tests made at Picatinny Arsenal by storing powder from twelve to fourteen months in leaky containers, have thus far indicated that it will absorb little or no moisture under such conditions. Some of the containers had tight fitting covers but no soldering strips, and others had holes in the covers. The conditions of storage varied from an ordinary magazine to places that were especially moist.

### ABSORPTION OF MOISTURE BY EXPLOSIVE "D"

In view of the fact that Explosive "D" which has absorbed moisture is somewhat more difficult to detonate, tests have recently been made on samples long stored at fortifications under the usual conditions. The results indicated that moisture is not readily absorbed under ordinary conditions of storage, the amount of moisture present in every sample tested being less than that permitted by the specifications for new explosive.

### MECHANICAL TIME FUZE

An experimental lot of mechanical time fuzes, whose operation is governed by clock work mechanism, is being procured from abroad for use in the 6-pounder projectiles fired from the high velocity gun designed for the attack of aeroplanes. This fuze has been developed by the Krupp Company and is said to be the first successful fuze of the mechanical type.

The type has theoretical advantages and it is hoped may furnish a remedy for the difficulty heretofore encountered with mortar shrapnel fuzes, as well as with fuzes for every gun using a velocity much above 2000 f.s.

### MORTAR PROJECTILES AND LATE DECK ARMOR

Previous to the adoption of delay action primers for D.P. shell, tests were made to determine whether the weakest of the old type fuzes on hand, the A.P. detonating and torpedo detonating fuzes (modified Peirce stocks), could be expected to successfully withstand the stress to which they would be subjected during the perforation of late quality deck plates. The fuzes were thus found to be amply strong.

### LOT NUMBERING

A new system of lot numbering for projectiles within the continental limits of the United States was adopted some months ago, and has been published in Ordnance pamphlet No. 1872, *Seacoast Artillery Ammunition*. The system previously in use in the insular possessions was reasonably satisfactory and has not been changed.

The new system involves the following principles:

(a) A.P. shot and D.P. shell, i.e., projectiles using delay action fuzes, have odd lot numbers.

(b) A.P. shell, i.e., projectiles using quick acting fuzes, have even lot numbers.

(c) The same lot number applies to the same type of fuze, no matter in what caliber of projectile it may be used.

The lot number, therefore, serves to identify the type of fuze, and to indicate whether delay or non-delay. Thus all medium caliber base detonating fuzes used in standard A.P. shot, and the corresponding projectiles of whatever caliber, are designated as "Lot 1"; while all such fuzes used in standard A.P. shell and the corresponding projectiles, are designated as "Lot 4." As previously stated, the odd number indicates a delay action fuze and the even number indicates a non-delay action fuze. Armament Officers have been instructed to identify carefully all fuzes on hand at fortifications and to add metal labels to the boxes in which they are contained, in order that confusion may not arise in the future. The providing of metal labels for the boxes of fuzes and the stamping of lot numbers on the rotating bands, it is believed, will prevent serious confusion, if an occassion should arise for quickly assembling the fuzes to the projectiles.

### CARTRIDGE STORAGE CASES

An investigation as to the causes of the comparatively large number of leaks found in cartridge storage cases, has revealed the fact that the galvanizing tends to peel off; so that, when the soldering strip is applied to this surface, leaks are liable to develop. In future, storage cases will have the cover, soldering strip, and soldering ring terneplated, that is, coated with a lead and tin alloy, this having been found to improve greatly the holding power of the solder. A testing set has been manufactured and issued to each coast defense for use in testing each storage case for leaks at the time the shipment is

received and at such other time as may be desired. This will permit the early detection and correction of leaks developed during transportation. The handles will in future be omitted from storage cases, as they have been found to cause the development of leaks during the rolling of the cases from place to place.

### REGULATIONS FOR CARE AND TEST OF POWDER

There was published about six months ago and issued to the service in pamphlet No. 1888, a very important set of regulations—those governing the care and test of smokeless powder and other explosives in store at ordnance establishments and in service. These regulations contain detailed information in reference to conditions of storage, the tests to be made from time to time, the reports to be rendered when the tests are not satisfactory, and the safety precautions to be taken when they fall below specified limits.

The importance of these regulations to the Coast Artillery is evident from the fact that there are on hand or about to be issued to fortifications large quantities of Explosive "D," and of smokeless powder, besides large quantities of trinitrotoluol. The regulations provide for the issue of made up charges for guns, but of powder in bulk for mortars. All issues are to be made in cartridge storage cases, these to be tested after their receipt at fortifications to insure their being air tight. The cartridge bags and primers for mortar charges will be issued in sealed cans containing the approximate number required for the annual target practice of an organization.

The method of putting up the charges for mortars is still under consideration by the Coast Artillery authorities. It is my personal view that the most satisfactory method consists in making up each charge in three sections, easily detachable, the parts being of such weight that the detachment of one section will reduce the charge to the next lower zone, and the detachment of two sections will reduce it by two zones.

In as far as concerns smokeless powder at posts, the regulations provide that a sample of each lot must in general be kept under observation in each magazine in which the lot is stored. These samples must be replaced by others taken from the charges in storage, each year for fixed ammunition, and each six months for separate loading ammunition. A supply of powder of late manufacture has been ordered issued for each caliber for use in replacing the samples taken from the charges.

The test paper furnished consists of small strips of $\frac{1}{10}$-normal methyl violet paper, which gradually loses its color in the presence of the products of decomposition of smokeless powder. A fresh strip is put into the bottle each month but remains there two months, thus giving a continuous test by means of the overlapping samples. A monthly report is made of all tests of less than thirty days, that limit being so high as to involve no question as to the safety of the powder. When the test falls below twenty days, the powder must be segregated, in the absence of special instructions to the contrary. When the magazine temperature is likely to rise above 85° F., a maximum thermometer must be used, and report made of all readings above that temperature.

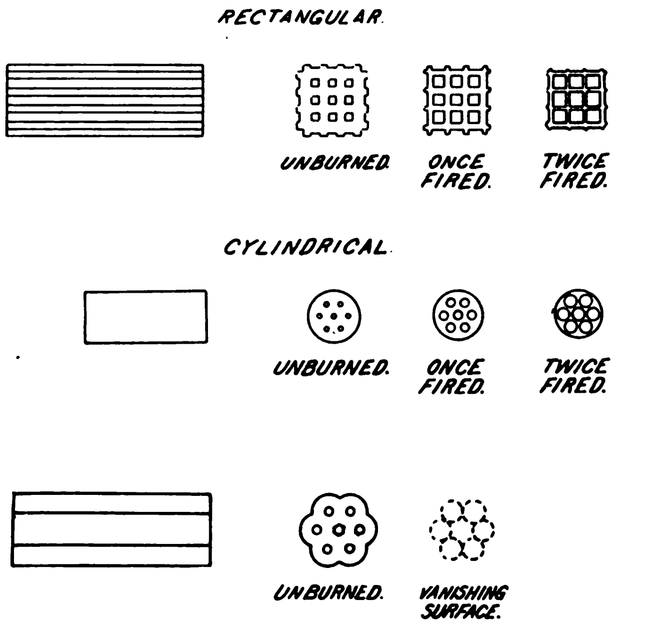



FIG. 8.
Powder grains for 8-inch guns

FORM OF POWDER GRAINS

Two new forms of powder grains of considerable promise have been proposed by officers of the Department and are now being manufactured for ballistic tests. One of these is of rectangular cross section containing rectangular perforations; and theother is a modification of the standard grain, by making the central hole and the outer cylindrical surface of a series of

arcs concentric with the intermediate holes (Fig. 8). Such grains theoretically burn without slivers and should reduce the charge or make possible an increased muzzle velocity without increasing the maximum pressure. The rectangular grain is objectionable in that the presence of the sharp corners tends to make it more brittle than the standard form. The other form has the same objection to a less extent and will probably not give in practice all the theoretical advantage, since there will be a tendency for the reentrant angles to disappear as the burning progresses, thus making the form tend towards the standard form. In order to increase the initial burning surface of the rectangular grains and to prevent them from packing so closely as to interfere with the satisfactory spread of ignition, a series of longitudinal ribs have been added to the outside of the grains of that form.

No conclusive data will be available until a suitable web thickness has been developed for some gun and firing tests made.

### METHOD OF FIRING GUNS

In accordance with the wishes of the Chief of Coast Artillery the Ordnance Department is at present engaged in working out the details of a firing system for seacoast guns embodying the principles of the one recently developed and tested by the Coast Artillery Board. The firing power is derived from a permanent magnet, A. C. generator to be operated by a short pull given to a firing lever by the gunner. To ensure safety against accidental direct currents, the primer circuit will operate through a one-to-one transformer fastened to the gun near the breech. With this system it is proposed to use habitually a simple electric primer, but to have a simple friction primer available for emergency use.

The Ordnance Department previously tested a number of magneto generators, but found none of the types tested sufficiently satisfactory for adoption.

### CAPTAIN GULICK'S ARTICLE

In a recent number of the JOURNAL OF THE UNITED STATES ARTILLERY (November-December, 1912) there appeared an article by Captain John W. Gulick, *Armor and Ships*, in which the author advocates four shell to one shot for 10-inch, 12-inch, and 14-inch guns. His conclusions are apparently chiefly based upon a table specifying the limiting ranges at

which perforation can be expected against armor 1-caliber thick, at normal impact and at 35° from the normal. The limiting ranges as given in that table (page 268, Vol. 38, No. 3, of the JOURNAL) are so inapplicable to the sharp pointed projectiles to be used in our next war that any conclusion based on them would be misleading.

The inapplicability arises from two causes:

1. The striking velocities are based upon the use of the short pointed projectiles. This is especially inappropriate in the case of the 14-inch gun, as no projectiles except those of the long pointed type have been manufactured for that caliber; and while the range tables have not been issued for the long pointed projectiles, yet since the ballistic coefficient has been commonly known for several years the necessary computations could have been readily made. The statement in the text that the limiting ranges given in the table should be increased "about 65 per cent" for the long pointed projectiles does not adequately cover the case, as will be pointed out later.

2. Captain Gulick based armor penetration upon projectile-test velocities instead of upon well established penetration formulæ. In order that the projectiles may be certain to have sufficient energy to perforate the plates, even with a considerable accidental drop in velocity, the projectile-test velocities are materially higher than those required to perforate. Thus the projectile-test velocity for the 14-inch A.P. shot against a 14-inch K.C. plate is 1745 f.s., whereas Hamilton's formula indicates that 1675 f.s. will give complete perforation. There is reason to believe that the lowest velocity that will give sufficient energy to perforate the plate is no more likely to break up the projectile than is a higher velocity. This is especially probable in as far as concerns oblique impact.

Captain Gulick's table of limiting ranges, as published in the JOURNAL, considering only the more important calibers, together with columns showing the 65 per cent increase stated to give the corresponding limits for long pointed projectiles, is given below. Data have been added showing the limiting ranges as computed for the long pointed projectiles by the usual formula of exterior ballistics and by Hamilton's penetration formulæ for K.C. armor. The corresponding data for the 14-inch 2250 f.s. gun have been included, as have data in reference to the 14-inch gun in the attack of 12-inch armor, since only a limited amount of thicker armor is carried by even the latest ships.

## Limiting Ranges in Yards for the Perforation of K. C. Armor as Given by Captain Gulick and by the Usual Formulæ

| Caliber and muzzle velocity | Thickness of plate | Velocity required to perforate at normal impact | | Limiting Range | | | Velocity required to perforate at 35 degrees from normal | | Limiting Range | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Capt. Gulick | | | | | Capt. Gulick | | |
| inches (ft. sec.) | inches | Assumed by Capt. Gulick | Computed by usual formula | Short point projectile | 65 per cent increase for long point | Computed by usual formula for long point | Assumed by Capt. Gulick | Computed by usual formulæ | Short point projectile | 65 per cent increase for long point | Computed by usual formulæ for long point |
| 12 (2250) | 12 | 1760 | 1669 | 5389 | 8892 | 9255 | 2024 | 1790 | 2433 | 4014 | 7150 |
| 14 (2150) | 12 | .... | 1542 | .... | .... | 11733 | .... | 1645 | .... | .... | 9500 |
| | 14 | 1745 | 1680 | 4550 | 7508 | 8700 | 2007 | 1795 | 1400 | 2310 | 6200 |
| 14 (2250) | 12 | .... | 1542 | .... | .... | 13350 | .... | 1645 | .... | .... | 11300 |
| | 14 | .... | 1680 | .... | .... | 10300 | .... | 1795 | .... | .... | 8000 |

The great variation between the results in Captain Gulick's table and those computed by the usual formulæ, is apparent from his giving the limiting range for the 14-inch, 2150 f.s. gun with long pointed projectile against 14-inch armor 35° from normal as 2310 yards, whereas the standard formulæ give that limit as 6200 yards.

### EXPERIMENTAL TARGET FIRINGS

In view of their great importance, there are briefly outlined here the series of firings which established the efficiency of our present types of A.P. projectiles and fuzes. This outline seems especially desirable in view of the differences of opinion that have developed in regard to the relative advantages of A.P. shot and A.P. shell for direct fire guns.

### 1. *Gathmann Tests*

The first series of tests were known as Gathmann tests. They are described and illustrated in the reports of the Chief of Ordnance for the year 1901. They were undertaken in 1901 and comprised competitive firings between the service 12-inch A.P. projectiles, filled with Explosive "D" and Maxi-

mite, and Gathmann 18-inch projectiles, weighing approximately 1834 lbs. and carrying 500 lbs. of wet guncotton. The targets represented battleship sections carrying 11.5-inch Krupp armor (Fig. 9). Three rounds were fired at each target, normal impact. As a result of the first and second Gathmann shots, the target was moved a few inches, and as a result of the third the plate was cracked vertically (Fig. 10). The first service 12-inch A.P. shot, 19-7/16 lbs. Explosive "D," passed through the plate and detonated immediately in rear, destroying the cellular structure and backing (Figs. 11 and 12). Parts

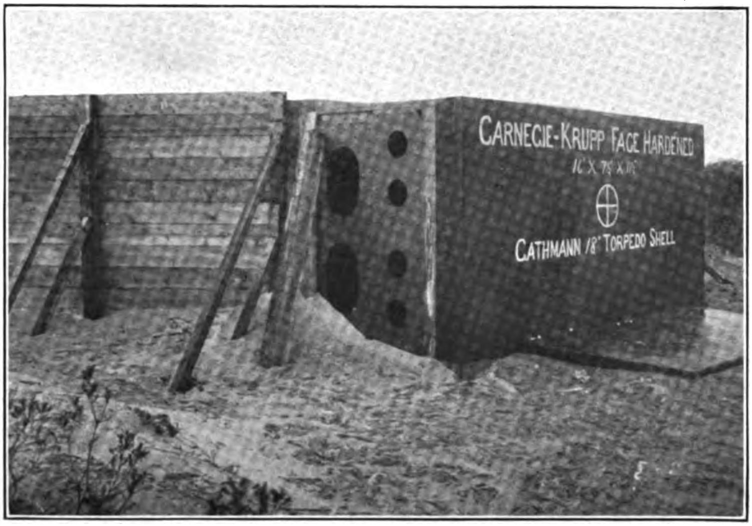



FIG. 9. 1321

of the plate and projectile were found 200 feet beyond the target. The second 12-inch A.P. shot, 23 lbs. Maximite, detonated in the plate after penetrating about 9½ inches. The right half of plate was wrecked and the cellular structure in rear was badly damaged. The third service round was 12-inch A.P. shell, 60-5/16 lbs. Explosive "D." It detonated after penetrating 6-inches. The lower left hand part of the plate was broken into six pieces. The target was a wreck (Fig. 13). Parts of the plate and of the projectile were found beyond the target. The Joint Army and Navy Board, by whom this test was made, reported: "There is nothing in the Gathmann system to recommend its adoption in the public service of the United States, or to warrant further experiments."

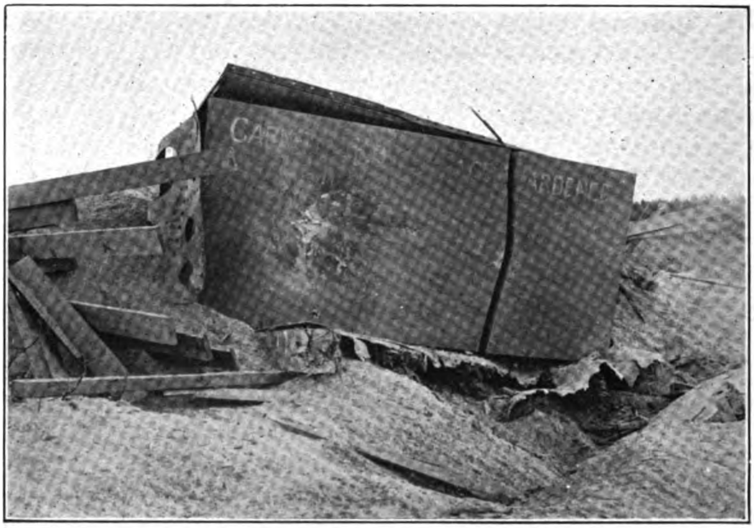


FIG. 10. 1322


FIG. 11. 1323

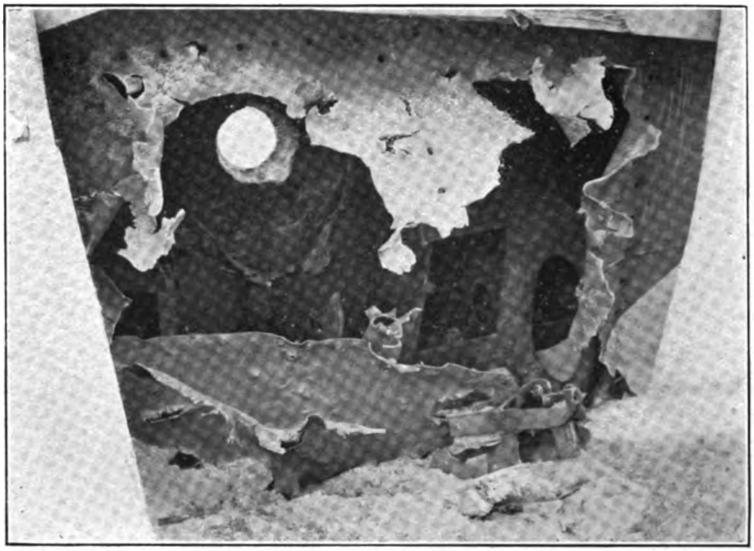


FIG. 12. 1324


FIG. 13. 1325

### 2. *Isham Tests*

The second series of tests were begun in 1898 but were not completed until 1905. They are known as the Isham tests, and are described in the reports of the Chief of Ordnance for 1899 and 1900. They comprised competitive firings between the service 12-inch A.P. projectiles and 12-inch Isham projectiles loaded with explosive gelatin. The Isham shell was of cast steel with a series of transverse diaphragms dividing it into short compartments, each of which was filled through a hole at the side, afterwards closed by a screw plug. The shell carried approximately 180 lbs. of explosive gelatin.

After preliminary firings with 7-inch howitzer shell, tests were undertaken with 12-inch projectiles in 1898, three, sand filled, being fired to test strength of shell, and four, charged with nitrogelatin, being fired with pressures ranging from 10,000 to 33,000 lbs. to determine safety against shock of discharge.

These were followed by one round at a 12-inch Harveyized plate 72 in. × 72 in., angle of impact 45° from the normal, striking velocity 1800 f.s. The plate unbroken was carried 17 feet along side of butt.

A 12-inch A.P. shot, sand filled, was next fired under identical conditions to obtain comparative data. The plate was broken into two nearly equal parts (Fig. 14). An Isham shell was then suspended against the face of a similar plate and fired electrically with no material injury to the plate, while another, buried in sand and exploded, gave a fair fragmentation.

In January, 1903, a gelatin charged shell was fired, with a pressure of about 46,000 lbs. per sq. inch. The charge was then increased to give a pressure of 50,000 lbs. per sq. inch for a second round. This burst in the gun after moving about 42 inches, blowing it into many fragments (Fig. 15).

The destruction of the 12-inch gun caused the abandonment of test of the Isham projectile till August 10, 1905, when a 12-inch Isham shell charged with 178.25 lbs. of gelatin was fired with a striking velocity of 1400 f.s. against a target representing a section of a modern battleship. The whole structure —plate, cellular structure, and backing—weighed about fifty-six tons. The plate, 11.5 in. × 16 ft. × 7.5 ft., Krupp. The impact was normal. A depression one and a half inches deep and twelve inches in diameter was the only damage to the plate. The entire structure was moved 4 inches to the rear.


FIG. 14. 1326

FIG. 15. 1327

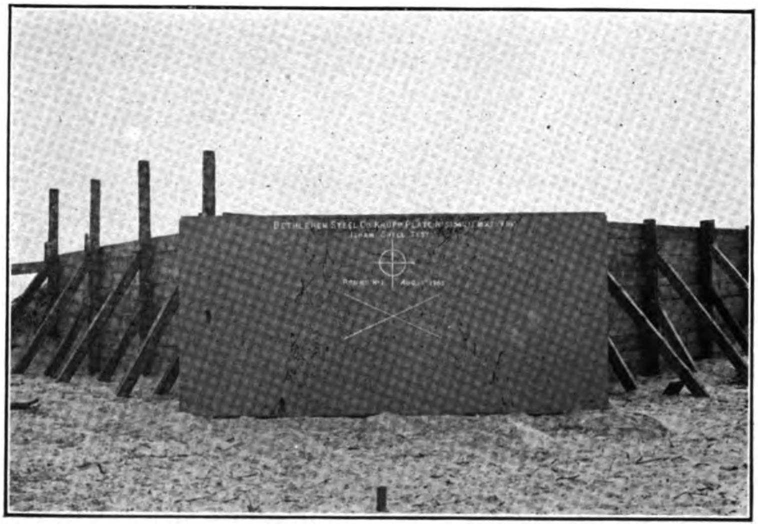


FIG. 16. 1328

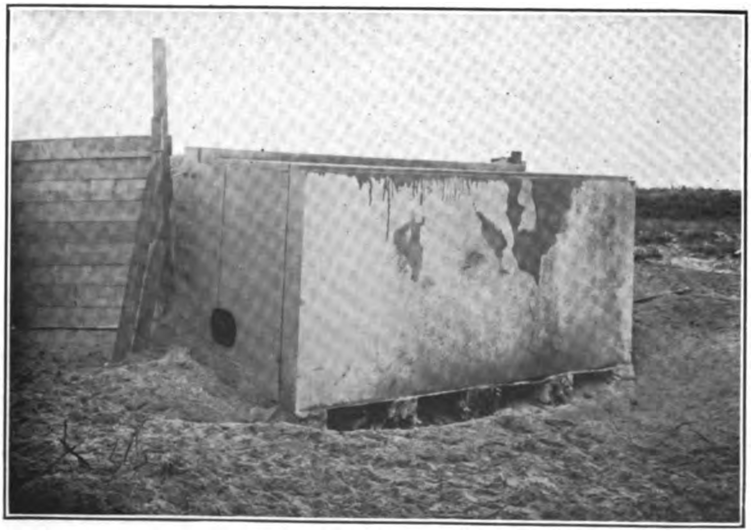


FIG. 17. 1329

A crater twenty-six inches deep was made in the sand in front of the plate and the ends of the timber sills badly cut up (Figs. 16 and 17).

Five pressure plugs seated in the bases of 6-inch projectiles, placed on end in the sand from four to eight feet from the center of the explosive, recorded pressures varying from 16,000 to 1800 lbs. per sq. in. However, only one of the 5 gauges was found undamaged by fragments and sand, and this recorded 4800 lbs. at 8 feet from the seat of the explosion.

In 1907 it was proposed to use the second shell furnished by Isham in 1905, for the purpose of testing his claim that the transmitted pressure on top of water would crush in the unarmored hull of a ship. A concrete tank was built at the foot of the battleship target, but the test was abandoned and the shell destroyed when a report was received from a prominent manufacturer that explosive gelatin subjected to heat and cold would probably exude nitroglycerin. As the Isham shell had been loaded two years and had been subjected to all the temperature changes of the Sandy Hook climate, its use was considered unsafe.

### 3. *Cruiser and Battleship Targets*

#### a. Cruiser Target

The third series of firings was made against one target representing a cruiser and against two targets representing battleships. The chief purpose of these firings was to determine how much damage might be expected from the oblique impact of a large shell assisted by the bursting charge which was to be detonated by a quick acting fuze. The striking angles and velocities used were such as would be encountered when the projectiles themselves were overmatched by the plates.

The cruiser target (Fig. 18) represented the side armor of a cruiser of the *Tennessee* class and consisted of a 5-inch and a 6-inch K.C. plate each 15¼ ft. × 8 ft. supported by timber and cellular shell representing a section of such a vessel. In addition there was an inclined protective deck plate of nickel steel three and a half inches thick, the angle made with the horizontal being 42°. The whole section was in turn supported by heavy timber backing designed to support the target against both a normal impact and an oblique impact from one side. All firings were intended to give a striking velocity

corresponding to a range of 10,000 yards, with the short pointed projectile. The test began with a 12-inch A.P. shell charged with 57 lbs. of Explosive "D" and a non-delay fuze. This was fired at an angle of impact of 21° measured from the face of the plate. It failed to penetrate, though large circular cracks were made around the point of impact (Fig. 19). A good detonation was secured. In order to determine how much of the injury could be attributed to the explosive, a second A.P. shell, *sand loaded*, was fired under about the same conditions. This not only failed to penetrate, but produced less serious cracks around the point of impact.

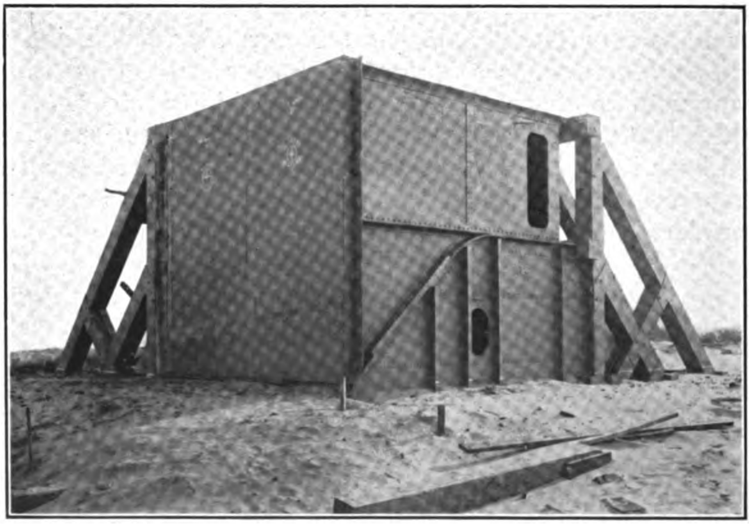


Fig. 18. 1330

Attention was next turned to the 5-inch plate, against which was first fired a sand filled 10-inch A.P. shell, angle of impact 20° from the surface of the plate. This produced no injury other than a few cracks (Fig. 20). The result of the 10-inch sand filled shell was so insignificant that a 12-inch A.P. shell charged with 58½ lbs. of Explosive "D" was next tried, the angle of impact being 21⅓° from the plate. The armor, teak backing, and backing plate were driven in (Figs. 21 and 22). No fragments passed through the walls of the cellular structure. The last shot justified trying a 10-inch A.P. shell under similar conditions. This failed to penetrate and the damage was slight.

The foregoing tests indicated that but little could be expected against a 6-inch plate within the angle of impact used, and the next two rounds at that plate were with an angle of 35° measured from the face of the plate, as compared with 20° previously used. One, a 12-inch A.P. *shot*, charged with 20

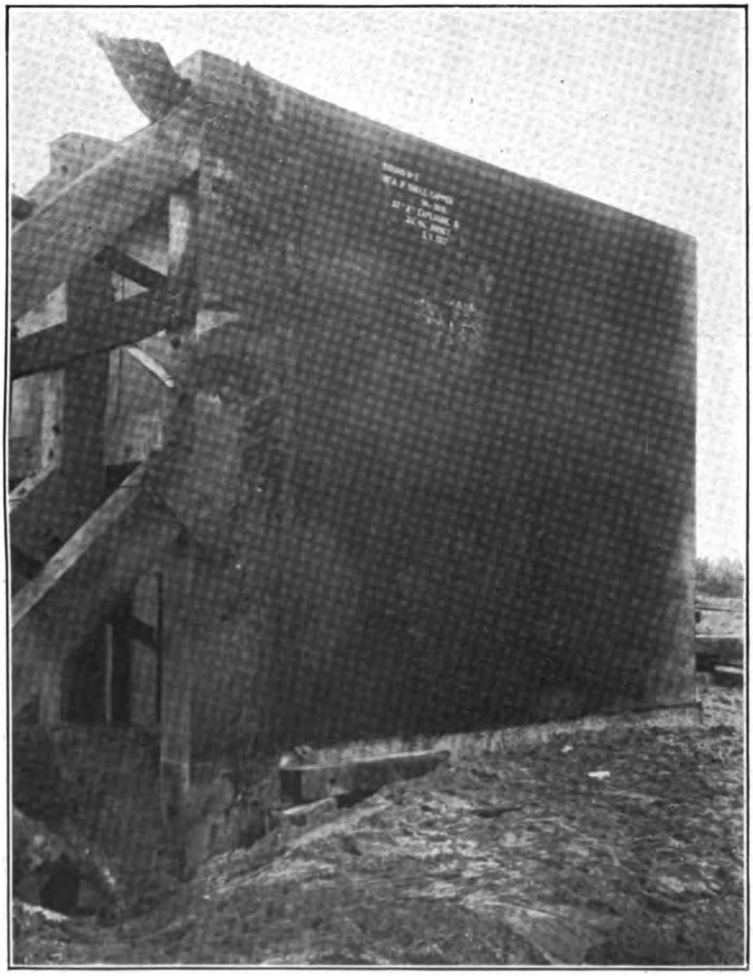


FIG. 19. 1331

lbs. of Explosive "D," failed to penetrate; but, as in round No. 1, produced circular cracks around the point of impact. The other, a 12-inch A.P. *shell*, charged with 58 lbs. of Explosive "D," also failed to penetrate and produced less effect than the shot.

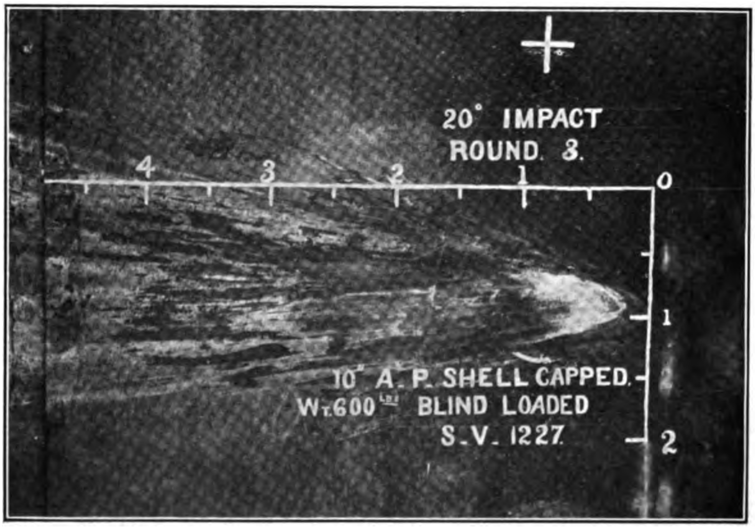



FIG. 20. 1332

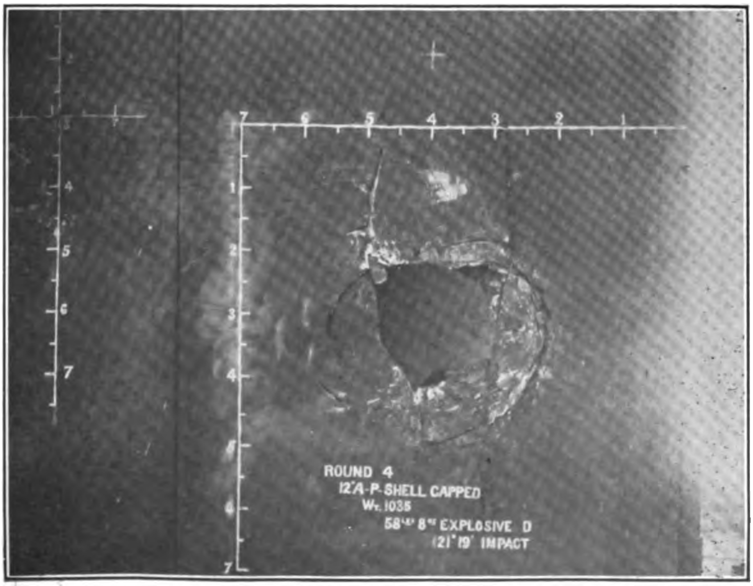



FIG. 21. 1333

From these seven rounds it was concluded, under the conditions of long range and very oblique impact, that secondary armor was protection against 12-inch charged shot and shell; also, that when the plate slightly overmatches the projectile, the latter may, nevertheless, break in the plate with the assistance of the bursting charge when the charge is detonated by a fuze sufficiently quick in its action to cause detonation while the projectile is in contact with the plate.

It yet remained to ascertain the effect of 12-inch shot and shell charged with Explosive "D" and equipped with the same type of quick acting fuze, when the angle of presentment was favorable for the projectile's remaining whole after penetration. It was also desired to determine the amount of protection

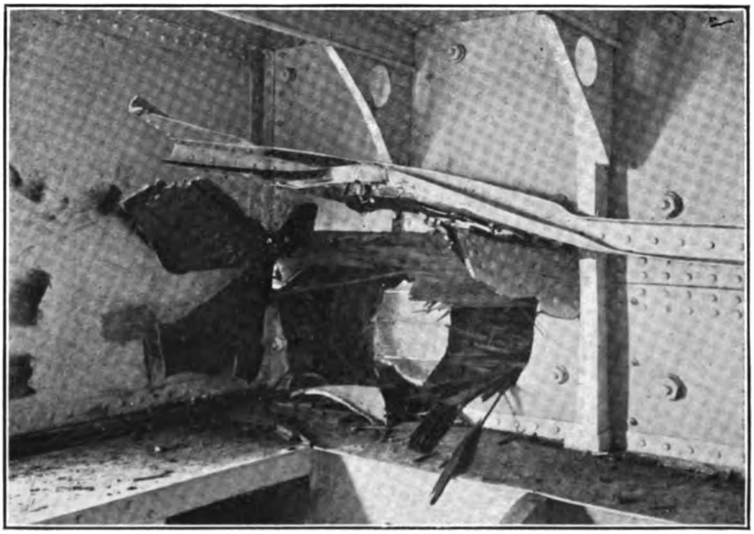


FIG. 22. 1334

afforded by the protective deck under these conditions. To determine these points:

(1) One 12-inch A.P. shell with 59 lbs. of Explosive "D" was fired against the 6-inch plate, normal impact, opposite the center of the protective deck plate. This detonated before penetration. No fragments of plate or projectile passed through the protective deck, but glancing from it penetrated in several places the thin walls of the cellular structure (Figs. 23 and 24).

(2) One 12-inch A.P. shot with 20½ lbs. of Explosive "D" was fired under the same conditions against the 5-inch

plate. The 5-inch plate was somewhat more broken up but otherwise the results were the same.

From all nine shots it is concluded that with a projectile fuzed with a quick acting fuze, the explosion on armor will be on the surface, no matter how favorable the angle of impact, and the destructive effect confined largely to the point of impact.

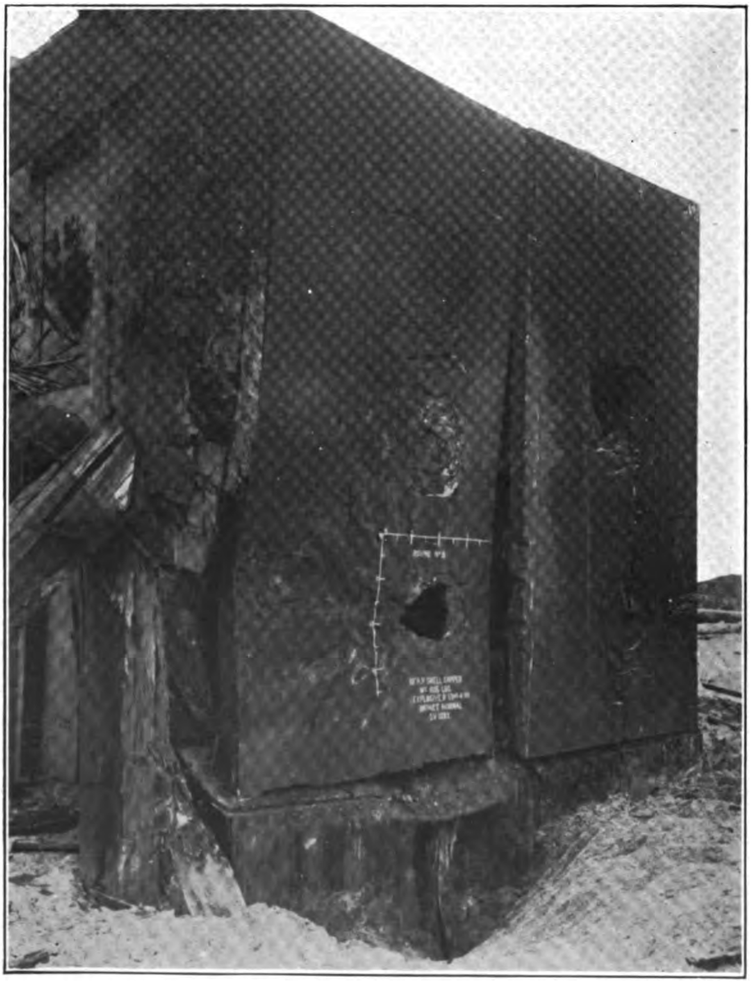


Fig. 23. 1335

b. Battleship Targets

Two targets were used in this test, each consisting of a waterline section of a battleship of the *Iowa* class (Fig. 25).

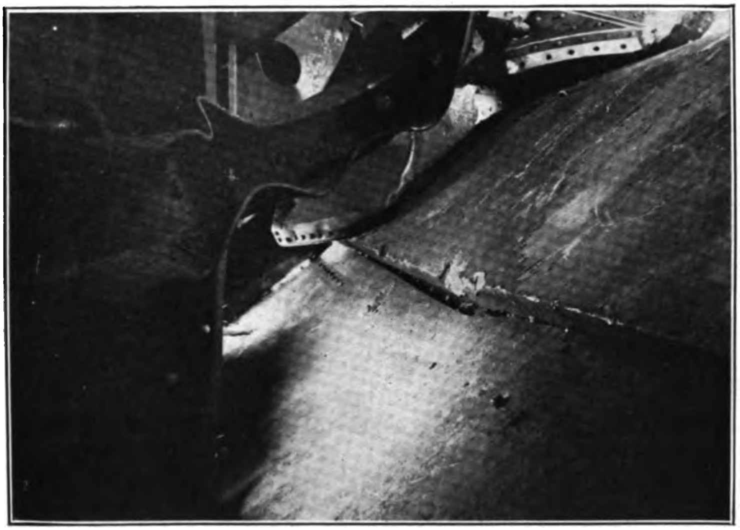


FIG. 24. 1336

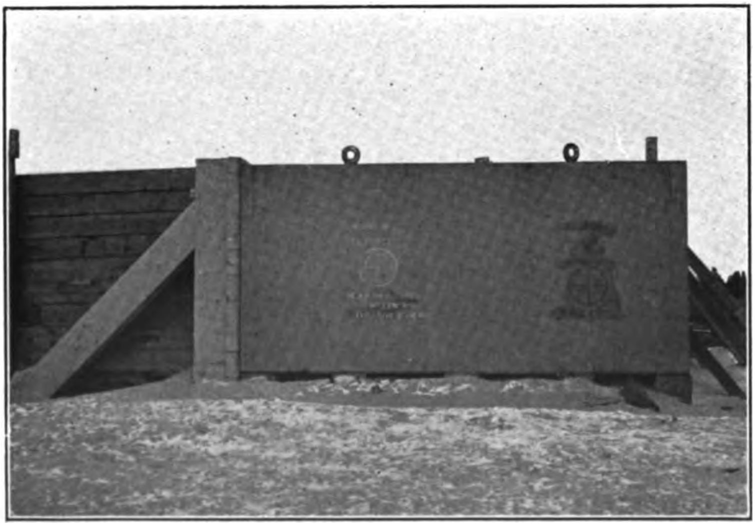


FIG. 25. 1337

The first was faced with a 12-inch K.C. plate 16 ft. long by 7½ ft. wide. The cellular structure and the backing were similar to those in the cruiser target.

At this, three 16-inch A.P. shell with about 132 lbs. of Explosive "D" were fired. The first at an angle of impact 20° from the face of the plate and a striking velocity of 1189 f.s., corresponding to a range of 15,000 yards. There was no penetration, but the plate was more or less cracked and a crater found at the foot of the target.

The result of this was so slight that a second shell was fired under the same conditions except that the angle was increased to 35°. Again the plate was not penetrated but the initial cracks were opened and new cracks formed. The cellular structure in rear showed a general setback of the plate and the beams, and tie plates were bent and bolts sheared.

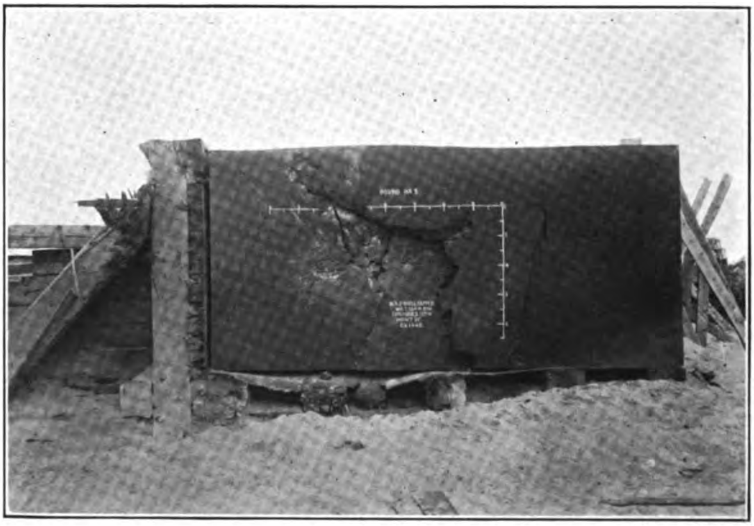


FIG. 26. 1338

For the third round the velocity was run up to 1448 f.s. corresponding to a range of 9700 yards, the remaining conditions being the same as in the second round. This also failed to penetrate, but the cumulative racking effect was sufficient to render the target unserviceable for further test (Fig. 26).

The second target (similar to the first, except that the plate was 11½ inches thick instead of 12 inches) was then so placed in front of the first target as to be supported by it against horizontal displacement. This target had already

been once fired at with an Isham 12-inch torpedo shell containing 178 lbs. of nitrogelatin, but was not materially deformed. It should be borne in mind, however, that all such heavy impacts seriously weaken the cellular supporting structure, and hence subsequent shots frequently show greater effectiveness than would have been the case had the target been new.

With a view to ascertaining the comparative effect of an A.P. shot upon such a plate (the previous rounds having been with shell), a 16-inch A.P. shot charged with 46 pounds of Explosive "D" was fired at this plate with the same striking velocity as in the previous shot, i.e., 1431 f.s., but with the angle of impact increased to 45°. As in all the previous firings, there was a surface detonation and the plate was not perforated. The racking effect upon the whole structure was great. The entire target was moved bodily and, in addition, revolved through an angle of 12°. A decided crater was formed in front of the target.

To ascertain how much of this was due to the explosive, a second A.P. shot, sand filled, was fired under identical conditions. The effect was much less pronounced, even though the second shot had the advantage of a weakened cellular structure.

### THE BATTLE OF TSUSHIMA

The almost hysterical account of the Battle of Tsushima given by Semenoff, and comments on the same battle appearing in part in "Professional Notes" in the JOURNAL, Jan.-Feb., 1910, ascribe miraculous results to the explosive used by the Japanese.

The fragments of a projectile which breaks up either from its explosive or upon impact on superior armor are most destructive to upper works and other light material. In the *San Marcos* tests a 12-inch cast steel target shell breaking up on impact with a turret was quite as destructive as any of the h.e. shot later fired at the ship.

As for the fires on the Russian ships, it should be remembered that the U. S. fleet produced the same results at Santiago with black-powder-filled shell.

Judging from the three Russian vessels which sought shelter at Manila after the fight, the decks and all upper works of the fleet were covered with a coating of coal dust (coal was carried on decks and in every available space), which might

easily have been ignited, and that would account for Semenoff's report that the paint and even the armor were in flames.

It is the common practice of the Sandy Hook Proving Ground to erect wooden barriers around the point of impact in armor tests. There is no recorded case of these being ignited by the high explosive when the latter was used. They are frequently ignited, however, by the highly heated fragments of projectile and plate, and this independent of the explosive, for ignition occurs as frequently without explosive as with it.

The Battle of the Straits of Japan is constantly cited in favor of a quick acting fuze. But owing to the inferiority of the Russians in ordnance material and gunnery, the Japanese were able to conduct this fight as if at target practice; and the main point at issue is, not whether the Russian ships were finally sunk or disabled, but whether, considering the caliber and the great number of projectiles that struck the Russian ships and the relatively inferior armor of the latter, we are willing to be satisfied with the rate at which the damage was inflicted.

It is believed that had the Japanese been supplied with A.P. shot and delay action fuzes, the action would have been much shorter. The Japanese by a large volume of fire, maintained for several hours, finally destroyed some of the Russian ships. These Russian vessels would probably have been sunk or put out of action by the same quantity of fire with strong projectiles unfilled. This was practically the case with the Spanish fleet at Santiago and with the *San Marcos* in the recent experiments by the Navy Department. Had the Russian fire been effective, the Japanese vessels would not have had time to deliver the projectiles found necessary to destroy or disable the Russian ships. It is rumored that the Japanese have turned to A.P. shot with a fuze having a delay. If this rumor could be confirmed, it would prove that they themselves were not satisfied with the effect of shell with quick acting fuzes.

## CONCLUSION

Considering all the firings referred to above, it is believed that we may conclude:

(a) Where a projectile greatly overmatches a plate, a large bursting charge exploded on the surface of the plate will assist in perforating the armor at an angle of impact at which the projectile itself would not break in the plate.

(b) That from this angle up to the normal, a projectile provided with a non-delay fuze does not increase in efficiency as the angle of presentment improves.

(c) That most of the projectile and all of the explosive effect, other than that on the armor itself, are outside the armor with a projectile fuzed with a quick acting fuze.

(d) That the present delayed action fuzes in projectiles capable of penetrating armor whole, will cause detonations well behind the armor.

(e) The non-delay fuze is superior to the delay fuze only when the plate (for the particular angle of impact and striking velocity) slightly overmatches the projectile alone. Then the detonation of the charge on impact will assist the projectile in

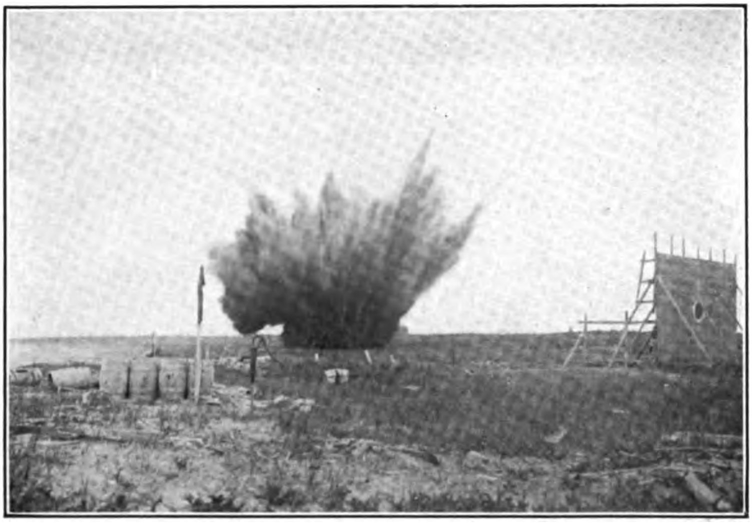


FIG. 27. 1339

breaking up the plate. When the plate largely overmatches the projectile under the same conditions of impact and velocity, the kind of fuze is immaterial. When the projectile overmatches the plate sufficiently to break through by impact alone, but breaks up in doing it, there is also little to choose between the two fuzes, since the detonation on the surface when a quick fuze is used will permit fewer projectile fragments to pass through the armor than would enter with the lower order of explosion with a delay fuze. At angles where penetration whole is possible, the delay fuze is markedly superior.

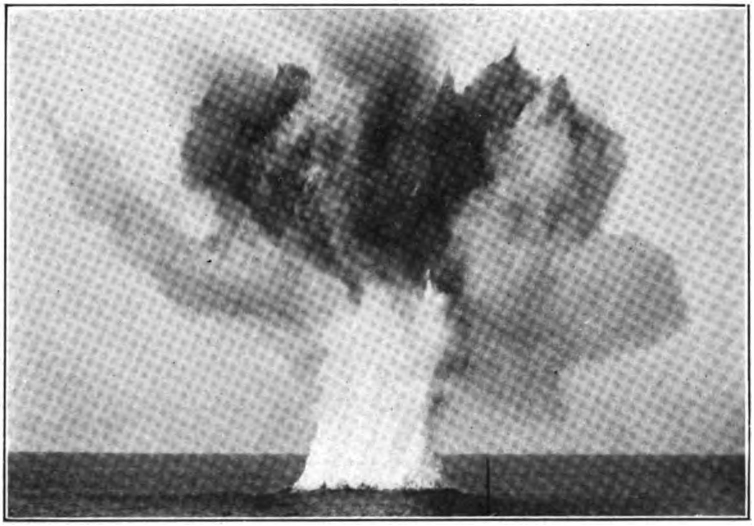


FIG. 28. 1340

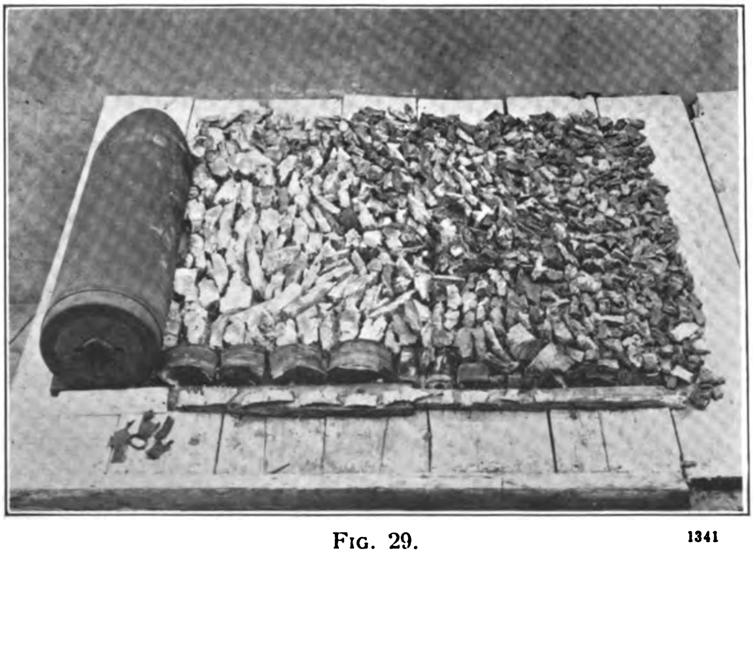


FIG. 29. 1341

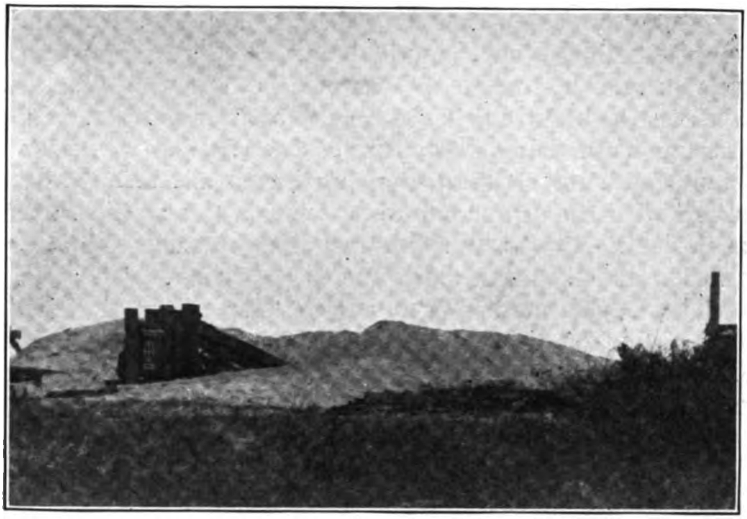


FIG. 30. 1342

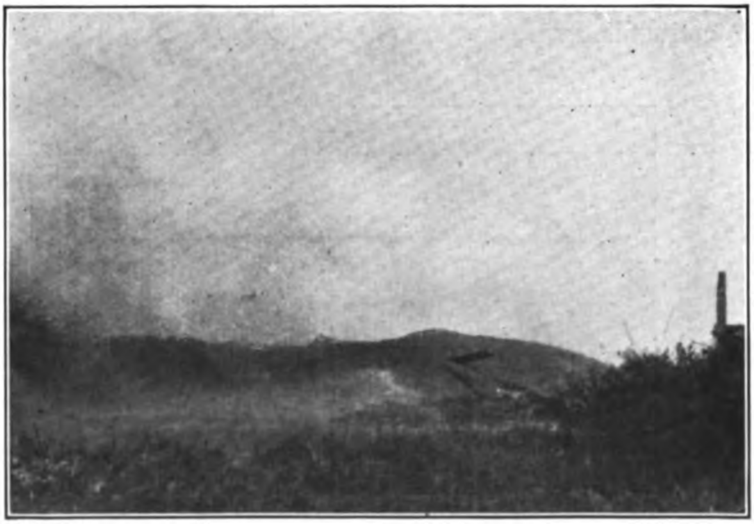


FIG. 31, 1343

It may be stated that A.P. shell, while tested to perforate armor ½-caliber thick, cannot be expected to perforate such armor in service, due to the use of a quick acting fuze which detonates the bursting charge very soon after contact. On the other hand, the delay action fuze of the A.P. shot so delays the action that shot striking glancing blows are usually out of contact with the armor before detonation takes place. When the projectile breaks up, whether shot or shell, a low order explosion usually takes place due to the shock.

The Department is trying to develop a fuze that will be quick acting on light impacts, such as glancing blows, and delay acting on striking a heavy plate. The design has not progressed sufficiently to give definite hope of success.

### HIGH EXPLOSIVE BURSTING CHARGE

There are presented three photographs, which illustrate the action of high explosive bursting charges in large caliber projectiles. The first (Fig. 27) shows the result of exploding a 12-inch A.P. shell filled with Explosive "D" and buried four feet in sand. The second (Fig. 28) shows the results with a similar shell suspended in water four feet below the surface. The third (Fig. 29) shows what happened to the shell as determined by a fragmentation test of a similar projectile in an explosion chamber where the fragments could be recovered.

I will bring my talk to a close by showing what happened to an armor plate when recently attacked by a 14-inch A.P. projectile filled with Explosive "D" (Figs. 30 and 31).

# NOTES ON BALLISTICS

## HIGH ANGLE FIRE

By Major ALSTON HAMILTON, Coast Artillery Corps

Recent firings by the Coast Artillery Board and by the Ordnance Department have thrown additional light on the flight of mortar projectiles; and as new range-tables have been prepared upon the basis of the results of these firings, it follows that the formulas and methods employed will be of interest to officers of Coast Artillery.

The notes here given will be limited to the presentation of formulas and methods and to the application of these to ordinary ballistic computations.

### I. Fundamental Quantities

1. It is usual in mortar fire to assume various muzzle velocities, each of which when taken with elevations ranging from 45° to about 65° will determine a zone covered by the fire of the mortar. A number of these zones, overlapping each other somewhat, will cover a total field of fire limited by conditions as to mortar and carriage. The basis, then, of a mortar range-table will be:

The muzzle velocity.
The angle of departure.
The projectile.

The muzzle velocity is represented by $V$, the angle of departure by $\varphi$ and the projectile by its ballistic coefficient, $C$, analytically defined as follows:

$$C = \frac{\delta_1}{\delta} \cdot \frac{w}{id^2}$$

in which,

$\frac{\delta_1}{\delta}$ is the ratio of the standard density to the actual density of the atmosphere. Its values are given in Table I, with barometer and thermometer readings as arguments.

$w$ is the weight of the projectile in pounds.

$d$ is the caliber of the projectile in inches.

$i$ is the index of the projectile and refers to its form. For the ordinary or Johnson cap, its value is unity for the purposes of this article, where the head has a two caliber radius of ogive; for the long pointed projectile, having an ogival head struck with a radius of 7 calibers, and no cap, the value of $i$ is *for mortar fire* 0.75.

The first value of $i$ (that for the cap) was assumed at the outset and the second was deduced from actual firings on the basis of laws established with the capped projectile.

2. With the ordinarily assumed law of resistance for the velocities usual in mortar fire, the retardation is represented by,

$$r = \frac{F(V)}{C} = .00004676 \frac{V^2}{C}$$

$$= [5.6699 - 10] \frac{V^2}{C}$$

This refers to a two-caliber radius of ogive, without cap. The actual firings with the capped projectile gave,

$$r = \frac{F(V)}{C} = K \frac{V^2}{C}$$

in which

$$K = .00005 \left\{ 1 - \frac{1}{4} \cdot \frac{100(V-800)}{100^2 + (V-800)^2} \right\}$$

$$= [5.6990 - 10] \left\{ 1 - \frac{1}{4} \cdot \frac{100(V-800)}{100^2 + (V-800)^2} \right\}$$

The values of log $K$, are given in Table II, page 188, for the zone-velocities. Its computation for any velocity presents no difficulty.

3. At the point of fall the relation between the range $X$ (feet) and the fundamental quantities was found to be,

$$\frac{V^2 \sin 2\varphi}{gX} = 1 + \frac{4}{3} \cdot \frac{F(V)}{gC} \cdot \lambda \sin \varphi$$

in which

$g$ is the acceleration due to gravity ( = 32.16 f.s. per sec.) and

$$\lambda \sin \varphi = \frac{2.4}{(1 + \sin 2\varphi)^{\frac{5}{3}}}$$

Values of log $\lambda \sin \varphi$ = log $E$ are given in Table III.

4. Representing by $M$ the ratio,

$$\frac{gX}{V^2 \sin 2\varphi}$$

and by $N$ the ratio,

$$\frac{gT}{2\,V \sin \varphi}$$

—in which $T$ is the time of flight, in seconds, to the point of fall, for which the range is $X$,—we have from the firings,

$$M = \frac{1}{1+B}$$

in which,

$$B = \frac{4}{3} \cdot \frac{F(V)}{gC} \cdot \lambda \sin \varphi, \text{ for all projectiles}$$

and

$$N = M\left(1 + \frac{V \sec \varphi}{10000}\right), \text{ for 1046-lb.}$$

$$N = 16.884\left(\frac{\sin \varphi}{V^2}\right)^{\frac{1}{5}} \text{ for 824- and 700-lb.}$$

5. The expressions for the remaining range-table elements as deduced from the firings are given below:

$$\text{Range (yards)} = R = \frac{M V^2 \sin 2\varphi}{3g} = \frac{M V^2 \sin 2\varphi}{96.48}$$

$$\text{Time of Flight (seconds)} = T = \frac{2\,N V \sin \varphi}{g} = \frac{N V \sin \varphi}{16.08}$$

$$\text{Drift (degrees)} = 2(1-K)\frac{d^3}{wn} \cdot \varphi^0 \sec \varphi$$

$$= p\,D \quad \text{(Tables IV and V).}$$

$$\tan \omega = \frac{\tan \varphi}{M}$$

$$\text{Velocity of Fall} = v_\omega = M^{\frac{3}{2}}\, V \cos \varphi \sec \omega$$

$$\left.\begin{matrix}\text{Thickness of Deck}\\ \text{Steel perforated}\end{matrix}\right\} = e = [5.4175 - 10]\sqrt{\frac{w v_\omega^3}{d}}\left\{1 - \left(\frac{90-\omega}{100}\right)^2\right\}$$

In these formulas $M$, $N$, $w$, $d$ are as already defined.

$K$ is a drift constant having a value (for projectiles with Johnson caps) $\frac{4}{5}$, and a value 0.837 for projectiles with 7-caliber radius of ogive.

$n$ is a drift constant, defining the twist of rifling, and as the mortar, model 1890 (and subsequent models), has a twist of one turn in 20 calibers, $n = 20$ for these. For the C.I. mortar, model 1886, and for the steel mortar, 1886-90, $n = 25$.

$e$ is the thickness of deck steel perforated, and is in inches. $v_\omega$ and $\omega$ are the velocity of fall and the angle of fall, respectively. In the value of $e$ the factor,

$$1-\left(\frac{90-\omega}{100}\right)^2$$

takes cognizance of oblique impact on the horizontal deck, due to the angle of fall. Thus its value for a 60° angle of fall is,

$$1-\left(\frac{90-60}{100}\right)^2=1-.09=0.91$$

The drift is given in degrees. The values of $D = \varphi \sec \varphi$ are tabulated and shown in Table IV, and those of $p = 2(1-K)\dfrac{d^3}{wn}$ are shown in Table V.

In Table II we shall give,

$$\log \frac{F(V)}{V^2} = \log K$$

$$\log F(V) = \log K V^2$$

$$\log \frac{4}{3} \cdot \frac{F(V)}{g} = \log H$$

and in Table I

$$\log \lambda \sin \varphi = \log E$$

so that

$$B = \frac{HE}{C}$$

$$M = \frac{1}{1+B}$$

## II. Corrections for Abnormal Conditions

The range-tables as calculated above apply when normal conditions exist; that is, when the muzzle velocities and air density are those presumed in the range-table, and when there is no motion of the atmosphere.

As these conditions are ideal, it is necessary to provide means of adapting the elevations to actual conditions.

Formulas for this purpose are readily found as follows:

$$\frac{1}{M} = \frac{V^2 \sin 2\varphi}{gX} = 1 + \frac{4}{3} \cdot \frac{F(V)}{gC} \cdot \lambda \sin \varphi$$

$$= 1 + \frac{4}{3} \cdot \frac{V^2}{C} \cdot \frac{K}{g} \cdot \lambda \sin \varphi$$

Simple differentiation gives,

$$\frac{1}{M}\left(\frac{2\,dV}{V}+\frac{d\sin 2\varphi}{\sin 2\varphi}-\frac{dX}{X}\right)$$
$$=\left(\frac{1}{M}-1\right)\left\{\frac{2\,dV}{V}-\frac{dC}{C}+\frac{dK}{K}+\frac{d\lambda\sin\varphi}{\lambda\sin\varphi}\right\}$$

Now

$$\lambda\sin\varphi=\frac{2.4}{(1+\sin 2\varphi)^{\frac{5}{3}}}$$

and hence

$$\frac{d\lambda\sin\varphi}{\lambda\sin\varphi}=-\frac{5}{3}\cdot\frac{d\sin 2\varphi}{1+\sin 2\varphi}$$

So that

$$\begin{aligned}\frac{dX}{X}&=2M\frac{dV}{V}-(1-M)\frac{dK}{K}\\&\quad+(1-M)\frac{dC}{C}\\&\quad+\left\{1+\frac{5}{3}(1-M)\frac{\sin 2\varphi}{1+\sin 2\varphi}\right\}\frac{d\sin 2\varphi}{\sin 2\varphi}\end{aligned}$$

This formula affords the means of making slight changes, but it is better to ascertain the effects by recalculating, using a modified $V$ or $C$ to accord with the facts.

Specifically, the abnormalities which, in practice, cause corrections to be necessary are:

1. Change in ballistic condition of powder due to storage.
2. Change in atmospheric density.
3. Motion of the atmosphere.

### 1. POWDER CHANGES

These are rather complex; but the matter is finally summarized by saying that a change in powder condition producing a 1 per cent range effect, either with the 1046-lb. projectile at 1050 f.s., or with the 824-lb. projectile at 1300 f.s., will produce changes in other zones as shown in Table $A$ on page 178.

It is to be noted that the percentage range correction having been determined for one zone, that for each of the others may be found by proportion. This applies to the first 7 zones and the zone with the 824-lb. projectile and muzzle velocity 1300 f.s., when the same powder is employed throughout. As a different (coarser) powder is employed with the 700-lb. projectile, the zones using this projectile are not so related to the others.

Table *A*

| Zone | $V$ | $\Delta R/R$ % |
|---|---|---|
| 1 | 550 | 1.93 |
| 2 | 600 | 1.84 |
| 3 | 660 | 1.80 |
| 4 | 725 | 1.80 |
| 5 | 810 | 1.70 |
| 6 | 915 | 1.40 |
| 7 | 1050 | 1.00 |
| 8 | 1300 | 1.00 |

2. ATMOSPHERE

$$\frac{dR}{R} = (1-M)\frac{dC}{C} = (1-M)\left(\frac{\delta_1}{\delta} - 1\right).$$

3. MOTION OF THE ATMOSPHERE

Due to the great altitudes reached by mortar projectiles in their flight, the mean direction and rate of motion of the atmosphere as a whole can only be inferred from the fall of the shots. At the same time, it has been practicable to demonstrate by analytical methods that the deflection produced by a 10-mile-per-hour lateral movement of the atmosphere will, in the case of each of the three mortar projectiles, produce a lateral motion on the part of the projectile, equivalent in effect to 8.7 per cent of the drift for that projectile. This is important in that it permits the cross wind-component to be readily inferred, and corrected by *making a percentage correction in the drift.*

In regard to the effect, on the range, of motion of the atmosphere in the plane of fire, exhaustive discussion of the subject shows

a. That the range effect of wind is sensibly constant in any zone, between 45° and 65°.

b. That in the case of the 12-inch mortar this effect in yards is given by,

$$\Delta R = 5W_x\left\{\frac{V}{1000}\right\}^2$$

in which $W_x$ is the velocity in miles per hour of the atmosphere in the direction of fire. Hence, for a 10-mile component,

$$\Delta R = 50 \left\{ \frac{V}{1000} \right\}^2$$

for all three projectiles.

## III. Illustrative Exercises

*Ex. 1.* Calculate the ranges for 45° and 65° for the 1046-lb. projectile, service, capped, for its range-table muzzle velocities.

$$\text{Here } C = \frac{1046}{144} = 7.2639$$

$$\log C = 0.8612$$

From Table II (page 188) obtain log $H$, and from Table III (page 189) log $E$.

Then, For 45°

| $V$ | 550 | 600 | 660 | 725 | 810 | 915 | 1050 |
|---|---|---|---|---|---|---|---|
| $\log H$ | 9.8332 | 9.9143 | 0.0042 | 0.0865 | 0.1227 | 0.1820 | 0.3198 |
| a.c. $\log C$ | 9.1388 | 9.1388 | 9.1388 | 9.1388 | 9.1388 | 9.1388 | 9.1388 |
| $\log \frac{H}{C}$ | 8.9720 | 9.0531 | 9.1430 | 9.2253 | 9.2615 | 9.3208 | 9.4586 |
| $\log E_{45}$ | 9.8785 | 9.8785 | 9.8785 | 9.8785 | 9.8785 | 9.8785 | 9.8785 |
| $\log B_{45}$ | 8.8505 | 8.9316 | 9.0215 | 9.1038 | 9.1400 | 9.1993 | 9.3371 |
| $B_{45}$ | .0709 | .0854 | .1051 | .1270 | .1380 | .1582 | .2173 |
| $1+B_{45}$ | 1.0709 | 1.0854 | 1.1051 | 1.1270 | 1.1380 | 1.1582 | 1.2173 |
| a.c.$\log(1+B_{45})$ | 9.9703 | 9.9644 | 9.9566 | 9.9481 | 9.9439 | 9.9362 | 9.9146 |
| $2 \log V$ | 5.4807 | 5.5563 | 5.6391 | 5.7207 | 5.8170 | 5.9228 | 6.0424 |
| $\log \frac{\sin 2\varphi}{3g}$ | 8.0156 | 8.0156 | 8.0156 | 8.0156 | 8.0156 | 8.0156 | 8.0156 |
| $\log R_{45}$ | 3.4666 | 3.5363 | 3.6113 | 3.6844 | 3.7765 | 3.8746 | 3.9726 |
| $R_{45}$ | 2928 | 3438 | 4086 | 4835 | 5977 | 7492 | 9389 |

For 65°

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $\log \frac{H}{C}$ | 8.9720 | 9.0531 | 9.1430 | 9.2253 | 9.2615 | 9.3208 | 9.4586 |
| $\log E_{65}$ | 9.9685 | 9.9685 | 9.9685 | 9.9685 | 9.9685 | 9.9685 | 9.9685 |
| $\log B_{65}$ | 8.9405 | 9.0216 | 9.1115 | 9.1938 | 9.2300 | 1.2893 | 9.4271 |
| $B_{65}$ | .0872 | .1051 | .1293 | .1562 | .1698 | .1947 | .2674 |
| $1+B_{65}$ | 1.0872 | 1.1051 | 1.1293 | 1.1562 | 1.1698 | 1.1947 | 1.2674 |
| a.c.$\log(1+B_{65})$ | 9.9637 | 9.9566 | 9.9472 | 9.9370 | 9.9319 | 9.9227 | 9.8971 |
| $2 \log V$ | 5.4807 | 5.5563 | 5.6391 | 5.7207 | 5.8170 | 5.9228 | 6.0424 |

| $V$ | 550 | 600 | 660 | 725 | 810 | 915 | 1050 |
|---|---|---|---|---|---|---|---|
| $\log \dfrac{\sin 2\varphi}{3g}$ | 7.8998 | 7.8998 | 7.8998 | 7.8998 | 7.8998 | 7.8998 | 7.8998 |
| $\log R_{65}$ | 3.3442 | 3.4127 | 3.4861 | 3.5575 | 3.6487 | 3.7453 | 3.8393 |
| $R_{65}$ | 2209 | 2586 | 3063 | 3610 | 4453 | 5563 | 6907 |

*Ex. 2.* The thermometer reads 79°, and the barometer 29.40 inches; what effect will this have on the ranges?

Table I gives

$$\frac{\delta_1}{\delta} = 1.050$$

Now,

$$\frac{dR}{R} = (1-M)\frac{dC}{C}$$

and, in this case,

$$\frac{dC}{C} = \frac{\delta_1}{\delta} - 1 = .050$$

The values of $M$ are the reciprocals of $1+B$, and a.c. log $(1+B)$ is log $M$. Consequently we have,

| $V$ | 550 | 600 | 660 | 725 | 810 | 915 | 1050 |
|---|---|---|---|---|---|---|---|
| $M_{45}$ | .9339 | .9213 | .9049 | .8874 | .8788 | .8634 | .8215 |
| $(1-M)_{45}$ | .0661 | .0787 | .0951 | .1126 | .1212 | .1366 | .1785 |
| $M_{65}$ | .9198 | .9049 | .8855 | .8650 | .8549 | .8370 | .7890 |
| $(1-M)_{65}$ | .0802 | .0951 | .1145 | .1450 | .1451 | .1630 | .2110 |

Hence the percentage range changes are,

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| At 45° | .00331 | .00394 | .00476 | .00563 | .00606 | .00683 | .00893 |
| At 65° | .00401 | .00476 | .00573 | .00725 | .00726 | .00815 | .01055 |

And the actual range changes are,

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| At 45° | 9 | 14 | 19 | 27 | 36 | 51 | 84 |
| At 65° | 9 | 13 | 18 | 26 | 32 | 46 | 73 |

*Ex. 3.* Calculate the values of log $H$, and of log $C$ for the following zones for the 12 inch mortar, model 1890.

(a) $V = 1300$
projectile 824 lb., Johnson cap

(b) $V = 1250$ }
(c) $V = 1500$ }
projectile 700-lb., long pointed, 7 cal. rad. ogive

| | (a) | (b) | (c) |
|---|---|---|---|
| $V-800$ | 500 | 450 | 700 |
| $(V-800)^2$ | 250000 | 202500 | 490000 |
| $100^2$ | 10000 | 10000 | 10000 |
| $100\ (V-800)$ | 50000 | 45000 | 70000 |
| $100^2 + (V-800)^2$ | 260000 | 212500 | 500000 |
| ratio | $\frac{5}{26}$ | $\frac{18}{85}$ | $\frac{7}{50}$ |
| ¼ ratio | $\frac{5}{104}$ | $\frac{9}{170}$ | $\frac{7}{200}$ |
| 1 − ¼ ratio | $\frac{99}{104}$ | $\frac{161}{170}$ | $\frac{193}{200}$ |
| log | 9.9786 | 9.9764 | 9.9845 |
| log $V^2$ | 6.2279 | 6.1938 | 6.3522 |
| a.c. log 20000 | 5.6990 | 5.6990 | 5.6990 |
| log $\frac{3}{4}g$ | 8.6176 | 8.6176 | 8.6176 |
| log $H$ | 0.5231 | 0.4868 | 0.6533 |
| log $w$ | 2.9159 | 2.8451 | 2.8451 |
| a.c. log $d^2$ | 7.8416 | 7.8416 | 7.8416 |
| a.c. log $i$ | 0.0000 | 0.1249 | 0.1249 |
| log $C$ | 0.7575 | 0.8116 | 0.8116 |

*Ex. 4.* Given,

$V = 1500$

$\varphi = 56°$

$R = 13875$ yards

700 lb. long pointed projectile

Calculate,

a. Time of flight.
b. Drift.
c. Angle of fall.
d. Maximum ordinate.
e. Velocity of fall.
f. Thickness of deck armor perforated.

Here,

a.
$$N = 16.884 \left(\frac{\sin\varphi}{V^2}\right)^{\frac{1}{5}}$$

$$T = \frac{2NV\sin\varphi}{g}$$

$$= 1.05\ V^{0.6}\ (\sin\varphi)^{1.2}$$

| | | |
|---|---|---|
| log 1.05 | = | .0212 |
| 0.6 log $V$ | = | 1.9057 |
| 1.2 log sin $\varphi$ | = | 9.9023 |

$$\log T = 1.8292$$
$$T = 67.48 \text{ sec.}$$

b.

| (1) | | (2) | |
|---|---|---|---|
| $2(1-K)$ | $= 2\times.163 = .326$ | | |
| log. .326 | $= 9.5132-10$ | $\log p$ | $= 8.6046-10$ Table V |
| $\log d^3$ | $= 3.2375$ | $\log D$ | $= 2.0006$ Table IV |
| a.c. $\log w$ | $= 7.1549-10$ | log Drift | $= 0.6052$ |
| a.c. $\log n$ | $= 8.6990-10$ | Drift | $= 4°.029$ |
| $\log \varphi \sec \varphi$ | $= 2.0006$ | | |
| log Drift | $= 0.6052$ | | |
| Drift | $= 4°.029$ | | |

c.
$$\frac{\tan \omega}{\tan \varphi} = \frac{1}{M} = \frac{V^2 \sin 2\varphi}{3gR}$$

Hence

| (1) | | (2) | |
|---|---|---|---|
| $\tan \omega = \dfrac{2\,V^2 \sin^2\varphi}{96.48\,R} = \dfrac{V^2 \sin^2\varphi}{48.24\;R}$ | | $\tan \omega = \dfrac{\tan \varphi}{M}$ | |
| $2 \log V$ | $= 6.3522$ | $\log 3g$ | $= 1.9844$ |
| $2 \log \sin \varphi$ | $= 9.8372$ | $\log R$ | $= 4.1422$ |
| a.c. $\log R$ | $= 5.8578$ | a.c. $2 \log V$ | $= 3.6478$ |
| a.c. log 48.24 | $= 8.3166$ | a.c. $\log \sin 2\varphi$ | $= 0.0328$ |
| $\log \tan \omega$ | $= 0.3638$ | $\log M$ | $= 9.8072$ |
| $\omega$ | $= 66°36'$ | a.c. $\log M$ | $= 0.1928$ |
| | | $\log \tan \varphi$ | $= 0.1710$ |
| | | $\log \tan \omega$ | $= 0.3638$ |
| | | $\omega$ | $= 66°36'$ |

d.
$$y_0 = \tfrac{1}{8} g T^2$$
$$= 4.02\, T^2$$

from (a) $2 \log T = 3.6584$

$\log 4.02 = .6042$

$\log y_0 = 4.2626$

$y_0 = 18306$ feet

e.
$$v_\omega = M^{\frac{3}{2}} V \cos \varphi \sec \omega$$

$3/2 \log M = 9.7108-10$

$\log V = 3.1761$

$\log \cos \varphi = 9.7476$

a.c. $\log \cos \omega = 0.4010$

$\log v_\omega = 3.0355$

$v_\omega = 1085$ f.s.

f. $$e = [5.4175-10]\sqrt{\frac{wv_\omega^3}{d}\left\{1-\left(\frac{90-\omega}{100}\right)^2\right\}}$$

$$\omega = 66.6$$
$$90-\omega = 23.4$$
$$\left(\frac{90-\omega}{100}\right)^2 = .055$$
$$1-\left(\frac{90-\omega}{100}\right)^2 = .945$$

$$\begin{aligned} \log w &= 2.8451 \\ 3 \log v_\omega &= 9.1065 \\ \text{a.c.} \log d &= 8.9208-10 \\ \hline & 2)10.8724 \\ \hline & 5.4362 \end{aligned}$$

$$\begin{aligned} \text{const} \log &= 5.4175-10 \\ \log .945 &= 9.9754 \\ \hline \log e &= 0.8291 \\ e &= 6.747 \text{ inches} \end{aligned}$$

*Ex. 5.* Firing of trial shots in zone 5 (1046 lb., 810 f.s.) with barometer 29.4 and thermometer 79°, showed a range 6100 yards at 45°. Atmosphere still and clouds motionless.

(a) What part of this was due to powder?

(b) What percentage correction should be made for powder in each zone?

(a) *Ex. 2* shows that 36 yards of this was due to air density; so that the range, all conditions normal except powder, was 6100 − 36 = 6064

*Ex. 1* shows that the range-table range is 5977 yards. Hence the shot ranged too far by

$$6064 - 5977 = 87 \text{ yards} = 1.45\%$$

Table A (page 178) shows 1.70 per cent as corresponding for this zone to one per cent in the 7th and 8th zones. Hence the percentage figures should be multiplied by

$$\frac{1.45}{1.70} = \frac{29}{34}$$

giving:

| Zone | Effect | Correct on |
|---|---|---|
| 1 | 1.65 % | −1.65 % |
| 2 | 1.56 % | −1.56 % |
| 3 | 1.53 % | −1.53 % |
| 4 | 1.53 % | −1.53 % |
| 5 | 1.45 % | −1.45 % |
| 6 | 1.19 % | −1.19 % |
| 7 | 0.85 % | −0.85 % |
| 8 | 0.85 % | −0.85 % |

*Ex. 6.* Shots were fired in the 6th zone (1046-lb. projectile, V = 915 f.s.) at an elevation 59°.

Four shots were fired at azimuth 230° and four at azimuth 290°.

The mean ranges and deflections observed were:

| | At az. 230° | At az. 290° |
|---|---|---|
| Range | 6628 yards | 6670 yards |
| Deflection | 4°.70 | 3°.58 |

The barometer stood at 28.50 and the thermometer at 70°.

The range table shows for this zone and elevation,

Range—6532 yards
Drift— 3°.79

(a) Find mean direction and rate of motion of the atmosphere.

(b) Find the percentage range correction due to powder in this and other zones.

Let $A$ be the azimuth of the direction *towards* which the atmosphere is moving. Then $A$-180° will be the azimuth *from* which it comes, or its "azimuth."

Then if $W$ be the rate of motion of the atmosphere in miles per hour, and $\Delta R_v$ be the effect in yards on the range of the change in condition of the powder, we shall have,

| | Az. 230° | Az. 290° |
|---|---|---|
| Deflecting component of $W$, | $W \sin(A\text{-}230°)$ | $W \sin(A\text{-}290°)$ |
| Range component of $W$, | $W \cos(A\text{-}230°)$ | $W \cos(A\text{-}290°)$ |

or, representing $A$-290° by $\alpha$,

| | | |
|---|---|---|
| Deflecting component | $W \sin(\alpha+60°)$ | $W \sin \alpha$ |
| Range component | $W \cos(\alpha+60°)$ | $W \cos \alpha$ |

To reduce these components to *effects* in yards, it is necessary to note that:

The deflection due to a 10-mile wind is 8.7% of the drift.

The range effect due to a 10-mile wind is given by

$$\Delta R = 50\left(\frac{V}{1000}^2\right)$$

$$= 50\left(\frac{915}{1000}\right)^2$$

$$= 42 \text{ yards in this case}$$

The deflection for 10-miles per hour is,

$$.087 \times 3.79$$
$$= 0°.33$$

The actual deflections not due to drift are:

| Az. 230° | Az. 290° |
|---|---|
| $4^\circ.70 - 3.79 = 0.91$ | $3^\circ.58 - 3.79 = -0^\circ.21$ |

The actual range effects due to all causes were:

| Az. 230° | Az. 290° |
|---|---|
| $6628 - 6532 = 96$ yds | $6670 - 6532 = 138$ yards |

The deflection components should produce effects:

$$W \sin(\alpha + 60) \times .033 = 0^\circ.91 \qquad W \sin \alpha \times .033 = -0^\circ.21$$

That is,

$$W(\sin\alpha \cos 60^\circ + \cos\alpha \sin 60^\circ) = \frac{0.910}{0.033}$$

$$W \sin\alpha = \frac{-0.210}{0.033}$$

Now,

$$\cos 60^\circ = \tfrac{1}{2} \text{ and } \sin 60^\circ = \tfrac{1}{2}\sqrt{3}$$

Consequently,

$$W\left\{\frac{\sin\alpha}{2} + \sqrt{3}\frac{\cos\alpha}{2}\right\} = 25.78$$

$$W \sin\alpha = -\ 6.36$$

By division, $\tfrac{1}{2} + \tfrac{1}{2}\sqrt{3} \cot\alpha = \dfrac{-25.78}{6.36}$

$$\tfrac{1}{2}\sqrt{3} \cot\alpha = \frac{-(25.78 + 3.18)}{6.36}$$

$$= \frac{-28.96}{6.36}$$

So that, $\tan\alpha = -\dfrac{6.36}{28.96} \cdot \dfrac{\sqrt{3}}{2}$

| | |
|---|---|
| $\log -6.36$ | $= 0.8035_n$ |
| a.c. $\log 28.96$ | $= 8.5382 - 10$ |
| $\log \sqrt{3}$ | $= 0.2386$ |
| a.c. $\log 2$ | $= 9.6990 - 10$ |
| $\log \tan\alpha$ | $= 9.2793_n - 10$ |
| $\alpha$ | $= -10^\circ 46'$ |

The effect of

$$\delta_1/\delta = 1.063$$

on the range is given by *Ex. 2* for this zone as follows:

For 5% $\Delta R = 48.5$
for 6.3 $\Delta R = 61$ yards

Hence the real range effects of powder and motion of the atmosphere are,

$$96 - 61 = 35 \text{ yards, and } 138 - 61 = 77 \text{ yards}$$

These effects, in view of the fact that 1 mi. per hr. produces a range effect 4.2 yards, may be used as follows:

$$\Delta R_v + 4.2\, W \cos(\alpha + 60°) = 35$$
$$\Delta R_v + 4.2\, W \cos \alpha = 77$$

By subtraction,

$$4.2\, W \{\cos(\alpha + 60°) - \cos \alpha\} = -42 \text{ yards}$$

or

$$W \{\cos(\alpha + 60°) - \cos \alpha\} = -10$$

Now, $\alpha = -10° \ 46'$

$\alpha + 60° = 49° \ 14'$

$\cos(\alpha + 60°) = 0.6529$
$\cos \alpha = 0.9824$
$\cos(\alpha + 60°) - \cos \alpha = -0.3295$

Hence,

$$W = \frac{-10}{-0.3295}$$
$$= 30.4 \text{ mi. per hour.}$$

$$\begin{aligned} \Delta R_v &= 77 - 4.2\, W \cos \alpha \\ &= 77 - 4.2 \times 30.4 \times 0.9824 \\ &= 77 - 125 \\ &= -53 \text{ yards} \end{aligned}$$

Hence the percentage change due to powder is,

$$\frac{-53}{6532} = -0.81\%$$

Hence, (a) Azimuth =

$A - 180° = 290° + \alpha - 180° = 99°.$
$W = 30$ mi. hr.

(b) Percentage change in range in this zone $-0.81\%$.
Percentage change in other zones, from Table A:

| Zone | | Effect | Correction |
|---|---|---|---|
| I | $1.93 \times \frac{-81}{140}$ | $= -1.12;$ | $+1.12\%$ |
| II | $1.84 \times$ " | $= -1.07;$ | $+1.07\%$ |
| III | $1.80 \times$ " | $= .04;$ | $+1.04\%$ |
| IV | $1.80 \times$ " | $= -1.04;$ | $+1.04\%$ |
| V | $1.70 \times$ " | $= -0.98;$ | $+0.98\%$ |
| VI | $1.40 \times$ " | $= -0.81;$ | $+0.81\%$ |
| VII | $1.00 \times$ " | $= -0.58:$ | $+0.58\%$ |
| VIII | $1.00 \times$ " | $= -0.58;$ | $+0.58\%$ |

(REMARK: Had no allowance been made for wind it would have been presumed that the average effect due to powder was,

$$\frac{35+77}{2} = +56 \text{ yards}$$

and a percentage correction in the various zones *in exactly the opposite* direction, and almost equal in amount would have been made, and in firing on a different day a large error would have been made in powder correction with no assurance of a compensating wind. Even on the same day, large errors would have been made in other zones; and some error even in this zone.)

### TABLE I

Values of $\delta_1/\delta$ for temperature and pressure of atmosphere 78% saturated with moisture. (From Artillery Note No. 25.)

| Ther. F. | Barometer 28″ | 29″ | 30″ | 31″ | Ther. F. | Barometer 28″ | 29″ | 30″ | 31″ |
|---|---|---|---|---|---|---|---|---|---|
| ° | | | | | ° | | | | |
| −20 | 0.890 | 0.861 | 0.831 | 0.806 | 9 | 0.950 | 0.917 | 0.887 | 0.858 |
| −19 | 0.892 | 0.863 | 0.833 | 0.808 | 10 | 0.952 | 0.919 | 0.889 | 0.860 |
| −18 | 0.894 | 0.864 | 0.835 | 0.809 | 11 | 0.954 | 0.921 | 0.890 | 0.862 |
| −17 | 0.896 | 0.866 | 0.837 | 0.811 | 12 | 0.956 | 0.923 | 0.892 | 0.864 |
| −16 | 0.898 | 0.868 | 0.839 | 0.813 | 13 | 0.958 | 0.925 | 0.894 | 0.866 |
| −15 | 0.901 | 0.870 | 0.841 | 0.815 | 14 | 0.960 | 0.927 | 0.897 | 0.867 |
| −14 | 0.903 | 0.872 | 0.843 | 0.816 | 15 | 0.962 | 0.929 | 0.899 | 0.869 |
| −13 | 0.905 | 0.874 | 0.845 | 0.818 | 16 | 0.964 | 0.931 | 0.901 | 0.871 |
| −12 | 0.907 | 0.876 | 0.847 | 0.820 | 17 | 0.966 | 0.933 | 0.903 | 0.873 |
| −11 | 0.910 | 0.878 | 0.848 | 0.822 | 18 | 0.968 | 0.935 | 0.905 | 0.875 |
| −10 | 0.912 | 0.880 | 0.850 | 0.824 | 19 | 0.971 | 0.937 | 0.907 | 0.877 |
| − 9 | 0.914 | 0.881 | 0.852 | 0.826 | 20 | 0.973 | 0.939 | 0.909 | 0.879 |
| − 8 | 0.916 | 0.883 | 0.854 | 0.827 | 21 | 0.975 | 0.941 | 0.911 | 0.881 |
| − 7 | 0.918 | 0.885 | 0.856 | 0.829 | 22 | 0.977 | 0.943 | 0.912 | 0.883 |
| − 6 | 0.920 | 0.887 | 0.858 | 0.831 | 23 | 0.979 | 0.945 | 0.914 | 0.885 |
| − 5 | 0.922 | 0.889 | 0.860 | 0.833 | 24 | 0.981 | 0.947 | 0.916 | 0.887 |
| − 4 | 0.924 | 0.891 | 0.862 | 0.835 | 25 | 0.983 | 0.949 | 0.918 | 0.888 |
| − 3 | 0.926 | 0.893 | 0.864 | 0.836 | 26 | 0.985 | 0.951 | 0.920 | 0.890 |
| − 2 | 0.928 | 0.895 | 0.866 | 0.838 | 27 | 0.987 | 0.953 | 0.922 | 0.892 |
| − 1 | 0.930 | 0.897 | 0.868 | 0.840 | 28 | 0.990 | 0.955 | 0.924 | 0.894 |
| 0 | 0.932 | 0.899 | 0.870 | 0.842 | 29 | 0.992 | 0.958 | 0.926 | 0.896 |
| 1 | 0.934 | 0.901 | 0.871 | 0.844 | 30 | 0.994 | 0.960 | 0.928 | 0.898 |
| 2 | 0.936 | 0.903 | 0.873 | 0.845 | 31 | 0.996 | 0.962 | 0.930 | 0.899 |
| 3 | 0.938 | 0.905 | 0.876 | 0.847 | 32 | 0.998 | 0.964 | 0.932 | 0.902 |
| 4 | 0.940 | 0.907 | 0.878 | 0.849 | 33 | 1.000 | 0.966 | 0.934 | 0.903 |
| 5 | 0.942 | 0.909 | 0.880 | 0.851 | 34 | 1.003 | 0.968 | 0.936 | 0.906 |
| 6 | 0.944 | 0.911 | 0.881 | 0.853 | 35 | 1.005 | 0.970 | 0.938 | 0.907 |
| 7 | 0.946 | 0.913 | 0.883 | 0.855 | 36 | 1.007 | 0.972 | 0.940 | 0.909 |
| 8 | 0.948 | 0.915 | 0.885 | 0.856 | 37 | 1.009 | 0.974 | 0.943 | 0.911 |

| Ther. F. | Barometer 28″ | 29″ | 30″ | 31″ | Ther. F. | Barometer 28″ | 29″ | 30″ | 31″ |
|---|---|---|---|---|---|---|---|---|---|
| ° | | | | | ° | | | | |
| 38 | 1.011 | 0.976 | 0.945 | 0.913 | 70 | 1.082 | 1.044 | 1.009 | 0.977 |
| 39 | 1.013 | 0.978 | 0.947 | 0.915 | 71 | 1.085 | 1.046 | 1.011 | 0.979 |
| 40 | 1.015 | 0.980 | 0.949 | 0.917 | 72 | 1.087 | 1.048 | 1.013 | 0.981 |
| 41 | 1.017 | 0.982 | 0.951 | 0.919 | 73 | 1.089 | 1.050 | 1.015 | 0.983 |
| 42 | 1.019 | 0.984 | 0.953 | 0.921 | 74 | 1.092 | 1.053 | 1.017 | 0.985 |
| 43 | 1.021 | 0.987 | 0.955 | 0.923 | 75 | 1.094 | 1.055 | 1.019 | 0.987 |
| 44 | 1.023 | 0.989 | 0.957 | 0.925 | 76 | 1.096 | 1.057 | 1.022 | 0.989 |
| 45 | 1.026 | 0.991 | 0.959 | 0.927 | 77 | 1.099 | 1.059 | 1.025 | 0.992 |
| 46 | 1.028 | 0.993 | 0.961 | 0.929 | 78 | 1.101 | 1.062 | 1.027 | 0.994 |
| 47 | 1.030 | 0.995 | 0.963 | 0.931 | 79 | 1.104 | 1.064 | 1.029 | 0.996 |
| 48 | 1.033 | 0.997 | 0.964 | 0.933 | 80 | 1.106 | 1.066 | 1.031 | 0.998 |
| 49 | 1.035 | 0.999 | 0.966 | 0.935 | 81 | 1.109 | 1.068 | 1.033 | 1.000 |
| 50 | 1.037 | 1.002 | 0.968 | 0.937 | 82 | 1.111 | 1.071 | 1.035 | 1.002 |
| 51 | 1.040 | 1.004 | 0.970 | 0.939 | 83 | 1.114 | 1.074 | 1.038 | 1.005 |
| 52 | 1.042 | 1.006 | 0.972 | 0.941 | 84 | 1.116 | 1.076 | 1.041 | 1.007 |
| 53 | 1.044 | 1.008 | 0.974 | 0.943 | 85 | 1.119 | 1.079 | 1.043 | 1.009 |
| 54 | 1.046 | 1.010 | 0.976 | 0.945 | 86 | 1.121 | 1.081 | 1.045 | 1.011 |
| 55 | 1.048 | 1.012 | 0.978 | 0.947 | 87 | 1.124 | 1.083 | 1.047 | 1.013 |
| 56 | 1.050 | 1.014 | 0.980 | 0.949 | 88 | 1.126 | 1.086 | 1.049 | 1.016 |
| 57 | 1.053 | 1.016 | 0.982 | 0.951 | 89 | 1.129 | 1.089 | 1.053 | 1.018 |
| 58 | 1.055 | 1.018 | 0.984 | 0.952 | 90 | 1.131 | 1.092 | 1.055 | 1.020 |
| 59 | 1.057 | 1.020 | 0.986 | 0.954 | 91 | 1.134 | 1.094 | 1.057 | 1.022 |
| 60 | 1.059 | 1.022 | 0.988 | 0.956 | 92 | 1.136 | 1.096 | 1.059 | 1.025 |
| 61 | 1.062 | 1.025 | 0.990 | 0.958 | 93 | 1.139 | 1.099 | 1.062 | 1.027 |
| 62 | 1.064 | 1.027 | 0.992 | 0.960 | 94 | 1.142 | 1.102 | 1.064 | 1.029 |
| 63 | 1.066 | 1.029 | 0.994 | 0.962 | 95 | 1.144 | 1.105 | 1.066 | 1.031 |
| 64 | 1.068 | 1.031 | 0.996 | 0.964 | 96 | 1.147 | 1.107 | 1.068 | 1.033 |
| 65 | 1.071 | 1.033 | 0.998 | 0.966 | 97 | 1.149 | 1.110 | 1.071 | 1.035 |
| 66 | 1.073 | 1.035 | 1.001 | 0.968 | 98 | 1.152 | 1.112 | 1.074 | 1.037 |
| 67 | 1.075 | 1.037 | 1.003 | 0.970 | 99 | 1.155 | 1.115 | 1.076 | 1.040 |
| 68 | 1.078 | 1.040 | 1.005 | 0.973 | 100 | 1.157 | 1.117 | 1.079 | 1.042 |
| 69 | 1.080 | 1.042 | 1.007 | 0.975 | | | | | |

TABLE II

| $V$ | log $K$ | log $F\ (V)$ | log $H$ |
|---|---|---|---|
| 550 | 5.7349 − 10 | 1.2156 | 9.8332 − 10 |
| 600 | 5.7404 − 10 | 1.2967 | 9.9143 − 10 |
| 660 | 5.7475 − 10 | 1.3866 | 0.0042 |
| 725 | 5.7482 − 10 | 1.4689 | 0.0865 |
| 810 | 5.6881 − 10 | 1.5051 | 0.1227 |
| 915 | 5.6416 − 10 | 1.5644 | 0.1820 |
| 1050 | 5.6598 − 10 | 1.7022 | 0.3198 |
| 1250 | 5.6754 − 10 | 1.8692 | 0.4868 |
| 1300 | 5.6776 − 10 | 1.9055 | 0.5231 |
| 1500 | 5.6835 − 10 | 2.0357 | 0.6533 |

## TABLE III

Values of log $E$ = log ($\lambda \sin \varphi$).

| $\varphi$ | log $E$ | $\Delta$ | $\varphi$ | log $E$ | $\Delta$ |
|---|---|---|---|---|---|
| 45 | 9.8785 − 10 | 2 | 58 | 9.9161 − 10 | 61 |
| 46 | 9.8787 | 7 | 59 | 9.9222 | 65 |
| 47 | 9.8794 | 11 | 60 | 9.9287 | 70 |
| 48 | 9.8805 | 15 | 61 | 9.9357 | 75 |
| 49 | 9.8820 | 20 | 62 | 9.9432 | 80 |
| 50 | 9.8840 | 25 | 63 | 9.9512 | 84 |
| 51 | 9.8865 | 29 | 64 | 9.9596 | 89 |
| 52 | 9.8894 | 33 | 65 | 9.9685 | 94 |
| 53 | 9.8927 | 37 | 66 | 9.9779 | 99 |
| 54 | 9.8964 | 42 | 67 | 9.9878 | 104 |
| 55 | 9.9006 | 47 | 68 | 9.9982 | 110 |
| 56 | 9.9053 | 52 | 69 | 0.0092 | 116 |
| 57 | 9.9105 | 56 | 70 | 0.0208 | |

## TABLE IV

Values of log ($\varphi \sec \varphi$)
= log $D$

| $\varphi$ | log $\varphi \sec \varphi$ | $\varphi$ | log $\varphi \sec \varphi$ |
|---|---|---|---|
| 45 | 1.8037 | 58 | 2.0392 |
| 46 | 1.8210 | 59 | 2.0590 |
| 47 | 1.8383 | 60 | 2.0792 |
| 48 | 1.8558 | 61 | 2.1000 |
| 49 | 1.8733 | 62 | 2.1209 |
| 50 | 1.8909 | 63 | 2.1423 |
| 51 | 1.9087 | 64 | 2.1644 |
| 52 | 1.9267 | 65 | 2.1870 |
| 53 | 1.9448 | 66 | 2.2102 |
| 54 | 1.9632 | 67 | 2.2342 |
| 55 | 1.9818 | 68 | 2.2589 |
| 56 | 2.0006 | 69 | 2.2846 |
| 57 | 2.0198 | 70 | 2.3110 |

## TABLE V

Values of log $p$
Projectiles

| Mortar | $n$ | 1046-capped | 824-lb., capped | 700-lb., long pointed |
|---|---|---|---|---|
| 1890 | 20 | 8.5191 − 10 | 8.6257 − 10 | 8.6046 − 10 |
| 1886 | 25 | 8.4222 − 10 | 8.5288 − 10 | 8.5077 − 10 |

$$p = 2\,(1 - K)\frac{d^3}{wn}$$

Drift $= pD$

## First Honorable Mention, Essay Competition of 1912

# WHAT IS THE BEST TYPE OF PROJECTILE FOR THE EXISTING ARMAMENT OF THE UNITED STATES SEACOAST FORTIFICATIONS?

By 2nd Lieutenant DOUGLAS C. CORDINER, Coast Artillery Corps

A discussion of the best type of projectile for the existing United States seacoast fortifications is practically a discussion of the relative merits of the shot and the shell, whether one should be used to the exclusion of the other or whether both should be used. The problem is limited to a discussion of the existing armament, hence only 12-inch and guns of smaller caliber are to be considered. Could 14-inch or 16-inch guns be considered, the conclusions might be different.

If the ideal could be obtained, there would be no question but that the shot would be vastly superior to the shell, except in certain instances such as where the shell and its detonating effect are stronger than the opposing armor. If perforation could be obtained and if we could be reasonably sure of any percentage of perforation at all ranges and of detonation after perforation, the question would be a simple one. But there are so many factors, which can not be overlooked and which would seem to make perforation and delayed detonation so highly improbable, that the shell must be taken into consideration. Since perforation depends upon the angle of impact, and since proving ground tests cannot determine the angle of impact that may be expected when our guns are used against battleships, the conclusions to be drawn must be based largely upon theory. In our service shot and shell are both armor piercing, they both carry bursting charges, but due to the extra metal in the shot its bursting charge is much less than that of the shell. (For 12-inch guns about ⅓ as much.)

If the conclusions to be deduced in the following discussion are correct, then it would seem that the weight of explosive which the shell carries should be increased. If perforation is

not expected, then the armor piercing qualities of the shell should be abandoned. The weight of the explosive could then be increased to about 8 per cent of the weight of the shell. It is then believed that, even with the 12-inch shell, the racking effect of the present 16-inch shell with its large amount of explosive would be approached. With a high detonation occurring just as the shell starts to penetrate, while the armor is hot from the shock of impact and the molecules stretched to their limit of cohesion, the shell would probably tear the bolts and the armor backing and possibly break the plates themselves in pieces.

Taking the relative merits of the shot and the shell into consideration involves a consideration of: (1) the caliber of the armament; (2) the location of any battery with reference to the depth of navigable water covered; (3) the results of tests having the solution of this problem in view; (4) the results of recent battles; (5) the quality and quantity of armor to be attacked; (6) the location of a battery with reference to the angle at which the target must present itself; and in the case of 12-inch guns in the United States the question finally simmers down to a consideration of (7) the ranges at which each type of projectile is most effective. The question therefore becomes a local one and the type of projectile best suited to the seacoast armament of the United States should vary for each particular battery and each caliber of gun. In discussing the relative merits of shot and shell it will be assumed that all shot carry a delay action fuze and that all shell carry a non-delay action fuze.

The question of shot and shell for all guns below 12-inch is quickly settled; except in the case considered in the next paragraph, they should all be provided with shell and not shot. In the case of 8-inch and 10-inch guns of the major armament there is no hope that the projectile can perforate the primary armor of the ships of to-day; so for reasons to be discussed below, they must rely on shell to accomplish the maximum destruction. In the case of the guns of the mine defense, the attack is against vessels which have little or no armor, and experiments have shown that detonation by shell against plate to which it is superior is more destructive to the body of the ship than perforation followed by detonation.

The type of projectile best suited to the mortar is obvious and involves no discussion.

In such districts as that of the Potomac, where the depth

of navigable water approaches prohibits attack by heavily armored vessels, the supply of projectiles should be practically limited to shells. However, to guard against any possible chance of attack by a vessel of medium armor, it is probably best to supply the largest caliber of gun—the 10-inch, for instance—with shot.

Now, consideration of the subject of shot and shell for the 12-inch gun, leads to an investigation of all available data which has been gathered from time to time at the proving grounds. This data covers the use of shot and shell with delay and non-delay action fuzes, and from this data the following conclusions may be drawn.

1. Where shell is used and the projectile greatly overmatches the plate, explosions on the surface of the plate will assist in perforating the armor at an angle of impact at which the projectile itself would not break in the plate.

2. That from this angle up to the normal a projectile with a non-delay fuze does not improve in efficiency as the angle of presentment improves.

3. That a projectile armed with a non-delay fuze produces practically all its effects on the outside of the armor rather than inside.

4. That the maximum amount of damage will be produced by a projectile which will perforate and then detonate.

Further conclusions indicate that A.P. shot with delay fuzes are effective:

1. At greater angles of impact from the normal than A.P. shell, even against lighter armor.
2. At extreme ranges against secondary armor.
3. At long ranges against intermediate armor.
4. At short ranges against heavy armor.

It would, therefore, seem that shot should be used to the exclusion of shell. However, no consideration is taken here of the relative effect of shot and shell at long ranges against heavy armor. The following results were obtained at the proving grounds and seem to be typical of other results obtained under similar conditions.

One 12-inch A.P. shot equipped with .04 second delay action fuze and loaded with explosive D, striking at an angle of 45° from the face of a 12-inch K.C. plate, striking velocity 1978 f.s., produced the following results: low order explosion; penetrated plate 2¼ inches; plate flaked off around point of

impact and driven into backing; effect small. A 12-inch A.P. shell fired under similar conditions, except that the projectile was fuzed with a non-delay fuze, produced the following results: detonation; plate and backing moved back 3 inches on left edge; eight top filler pieces in rear of plate crushed and split; one split upright; long crack from bottom of plate upward 72 inches. The results were more effective than those obtained with shot. It is further proven by this and other data that perforation by shot cannot be expected at the greater ranges.

Now, a careful consideration of all data at hand shows that, while the result of any one shell striking armor which it will not perforate, is not very serious except where the projectile overmatches the plate, the continued effect of this type of projectile hitting would be vastly superior to the hitting effect of shot, which very probably would not bite and which would then suffer only a low order of explosion.

It is now clear that each type has its respective advantages and the question becomes, when shall each be used? The question is one of range and must be referred to the target as a whole, and not to any one particular point or part.

The only value of the shot at long ranges is its qualities for piercing the secondary armor. Will a projectile which pierces the secondary armor and then explodes disable the ship? It is believed not. Injury to the secondary armament of a ship is of little importance. Even if it were desired, that armament could be but seldom used in an attack on the sea-coast defenses of the United States. The reasons for this will be shown later. It may be assumed, therefore, that at long ranges the vitals of the ship are absolutely protected from shot, and all communications (except those to the range towers) above the vitals are so protected by armor as to present no chances of shot biting. Aside from the fire control system, the conning tower is the only important part above heavy armor that could be injured, and its armor and curvature is such as to prevent any possibilities of perforation at great ranges. The whole system of fire control by observation, however, is absolutely unprotected; the primary stations are located in the masts, against which the effect of shot with delay action fuse is practically nil. The secondary stations have the same exposure. With these shot away, which could be done easily by high explosive, and the fire control personnel killed by fragments or asphyxiated by the poisonous gases liberated from the shell, the system of fire control devolves

upon the individual turrets. This, again, causes an exposure of officers above the protected parts and thus increases the susceptibility to the effects of shell rather than shot. With the fire control personnel non-existent, with the terrific jar produced by the shell, accompained by some racking effect, the results on the personnel can be imagined: their ammunition would be thrown away and the only alternative would be for the ship to retire. The conditions described here are graphically illustrated by the account of Captain Vladimir Semenoff, who, on board the flag ship *Suvoroff*, was an eye witness of the Battle of Tsushima. He says:

> It seemed as if they were mines, not shells, which were striking the ship's side and falling on the deck. They burst as soon as they touched anything—the moment they encountered the least impediment in their flight. Hand-rails, funnel guys, topping lifts of the boats' derricks, were quite sufficient to cause a thoroughly efficient burst, and the splinters caused many casualties. Iron ladders were crumpled up into rings, and guns were literally hurled from their mountings. Such havoc would never be caused from the simple impact of a shell, still less by that of its splinters. It could only be caused by the force of the explosion. * * * * In addition to this there was the unusual high temperature and liquid flame which seemed to spread over everything. I actually watched a steel plate catch fire from a burst. Of course the steel did not burn but the paint on it did. Such almost incombustible materials as hammocks and rows of boxes drenched with water flared up in a moment.

In this battle, ships were rendered helpless by the action of the explosive power of the bursting charges used. It seems that perforation played only a minor part in bringing about such a decisive victory for the Japanese. While it is believed that the Japanese might have ended the battle in short order had they been provided with shot, and while it is believed that the fire effects were intensified by such things as coal (an unusual case) which was lying about on the decks, it must be remembered that the armor of the Russian ships was of a very inferior grade. It simply helps to prove that at greater ranges shell is superior to shot.

Again, looking at the problem from the standpoint of the battleship as a whole, taking the U. S. S. *Delaware* as a type, and assuming a slope of fall of 1 on 8.45, we have the following data: the area of the target is 7189 square feet when bow on; 12,416, when 30° off the bow; and 19,551 when broadside.

Of these areas 2843 square feet (39%), 6010 square feet (48.4%), and 9271 square feet (47.4%), respectively, are protected by armor from 2 to 12 inches thick. It is thus seen that less than one half of the target is armored; so that the proba-

bility that a shot which hits the target will strike against armor is less than 50 per cent. And the percentage of projectiles which do strike the target at an angle equal to or greater than the biting angle, will be very small. This is due to: (1) the great angle of fall at long ranges; (2) the curved armor aboard ship; and (3) the unfavorable angle at which the armor is presented to the coast gun when the ship is entering the harbor.

A study of the location of the forty-eight 12-inch batteries of the United States with reference to the angle at which the target must present itself when attempting to enter, discloses the fact that there are only ten at which the maximum range for an angle as favorable as 45° is as great as 6000 yards, and only seven at which the maximum range for an angle as favorable as 55° is as great as 6000 yards. It is thus seen that the approach to any of these batteries must be nearly bow on and as stated before, lessens the chances of shot hitting within the biting angle. This fact accounts for the statement that the secondary armament will not be used against sea coast defenses.

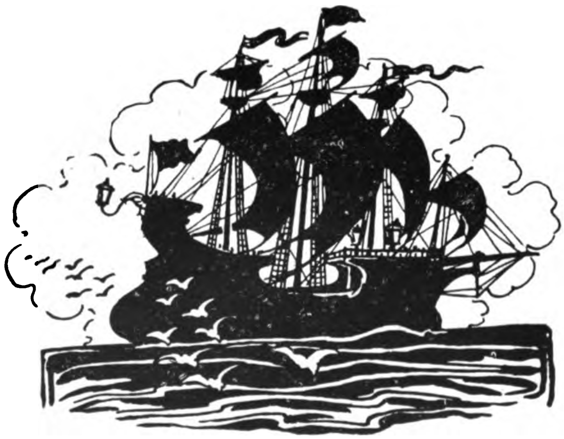
Recent tests on the *San Marcos* show that there is a tendency for projectiles which fall short to perforate below the armor belt. This is probably correct for ranges at which a ricochet occurs; but at the greater ranges the possibilities of an occurrence of this kind dwindles, and furnishes no real reason for the use of the shot at long range.

The problem narrows down. At what range shall shot be used and at what range shall shell be used? The statement has already been made that only perforation of the major armor and subsequent explosion can be expected to produce the best results; therefore, what is the range at which the 12-inch projectile will pierce the primary armor? Using the new long pointed cap, the penetration of 12-inch armor at normal impact is increased from about 6300 to about 9400 yards, and at 35° from the normal from about 5100 to about 7000 yards. As the normal can rarely be expected and as angles no better than 35° (due to angle of fall, to curved armor on ship board, and to the angle of approach) can usually be expected, it is believed that some range approximating 7000 yards should be used as the limiting range beyond which only shell should be used and inside of which only shot should be used against battleships. Owing to the fact that at the acceptance test for 12-inch projectiles, the limiting range (based on the striking velocity used) at which perforation must occur to insure acceptance of the lot at 35° impact to normal, is approxi-

mately 3000 yards or less, there is no real assurance that our projectiles will perforate beyond this short range. The limiting range might, then, be reduced to approximately 6000 yards.

Taking all things into consideration it is probable that most of the firing will occur beyond 6000 yards.

From the preceding discussion it may be concluded that two types of projectiles should be furnished the 12-inch batteries, which, with the mortars, constitute the chief source of seacoast defense in the United States, and that while the proportion of shell should exceed that of shot, the exact proportion for each battery should be determined separately.



# THE GROUPING OF MORTARS FOR CONTROL OF FIRE

By Major JAMES M. WILLIAMS, Coast Artillery Corps

The early volumes of the Journal contain many interesting articles on the subject of the typical mortar battery. In Volume 2, page 313, General Henry L. Abbot presents the subject in an article entitled "Vertical Fire"; in Volume 3, page 40, Captain E. L. Zalinski, under the same title, adds some remarks; in Volume 5, page 313, General Abbot, in the light of the data acquired in the service test of the mortar battery at Sandy Hook in 1895, continues his contribution under the title "Vertical Fire in Seacoast Batteries"; in Volume 7, page 287, under the title "Seacoast Mortar Fire," is published the report of a board of officers of which the purpose was to consider an adverse criticism of the typical mortar battery made by Lieutenant John T. Honeycutt; then in Volume 8, pages 129 and 142, respectively, Professor Mansfield Merriman and Lieutenant Honeycutt reply to the board's report. In Artillery Notes No. 23 the subject is again discussed by Majors Whistler and Harlow.

For the information of those young in the service, it may be well to state that the typical mortar battery comprised four pits of four mortars each, the pits being disposed at the angles of a rectangle of which the larger axis, lying in the direction of the principal field of fire, was 80 yards and the shorter axis 40 yards, the mortars in each pit being at the angles of a square of which the side was 20 feet. The division of the typical four-pit battery into two two-pit batteries resulted from the study of the subject by Majors Whistler and Harlow in 1904, above referred to.

The subject is still one of interest; for, notwithstanding the fact that our mortars are now fixed as to position, their grouping for control remains flexible, and it is possible that changed conditions render a change in grouping desirable. It is from this point of view that the present article is prepared.

General Abbot's first article was written for the purpose of acquainting artillery officers with the reasons for the design of the typical mortar battery, of which the first examples were then (1893) nearing completion in the harbors of Boston, New York, and San Francisco. General Abbot assumed: (1) a stationary target; (2) an accuracy of fire with mortars "about half of that with guns of like caliber." The data before him were: (1) "extensive use of vertical fire in the siege of Petersburg by the volunteer artillery troops under [his] command"; (2) "eleven records with the 28-centimeter (11.2-inch) mortar, made at the Krupp range at Meppen at various dates from March 14, 1879, to July 14, 1888"; (3) "nineteen records at Meppen, made with the 28.55-centimeter (11.4-inch) mortar in September, 1889"; (4) "six records of Russian practice made in 1885 with the 11-inch mortar"; (5) eleven records of Italian practice made with their 28-centimeter (11.2-inch) mortar between the years 1881 and 1884; (6) "eight ten-shot rectangles, the first five with the 12-inch mortar * * * and the last three with an experimental 12.2-inch mortar * * * all obtained at Sandy Hook in 1888-90. * * * the carriage was of an antiquated pattern"; (7) "some practice in Japan, at a range of two miles, on March 19-20, 1891," with a 28-centimeter (11.2-inch) howitzer and a 24 centimeter (9.5-inch) mortar. General Abbot's conclusion was in favor of the typical mortar battery and parallel fire; that is, laying all sixteen mortars with the same azimuth and elevation, determined for the center of the battery.

Captain Zalinski in 1894 assumed a moving target, but the smallest firing interval of which he expressed a hope was 4.4 minutes, stating, in a foot note, that the time for loading and firing the 12-inch mortar was then 11.5 minutes. He drew no definite conclusion, but merely voiced the opinion that experience would necessarily lead to modification of a system of fire based or *a priori* reasoning.

General Abbot's second article, as already stated, was based on the firing from a completed typical battery at Sandy Hook in 1895. This firing included fifteen pit salvos and two full battery salvos; but in the analysis of the pit salvos the impacts of the individual mortars were referred to the center of the pit as an origin, while in one of the two full battery salvos only ten impacts were identified. General Abbot also had before him at this time the records of firing which had been conducted at Sandy Hook in December, 1893, and April, 1894,

for the purpose of comparing the cast-iron steel hooped mortar with the all steel pattern, and in April and May, 1895, for the purpose of testing the accuracy of the latter. He states (page 320, Volume 5 of the JOURNAL) "that when mortars are grouped as in the battery at Sandy Hook, the area included in the probable rectangle will be seven or eight times as large as when the practice is from a single piece"; and on pages 323 and 324, referring to the typical battery, he concludes: "At last, however, the type stands completed; and it is my hope and belief that in the hands of artillery officers appreciating its theory and capabilities it will give a good account of itself in the next war."

About 1897 Lieutenant John T. Honeycutt, First Artillery, submitted to military authorities a paper in which he expressed an adverse opinion of a form of mortar battery founded upon the method of parallel fire. His contention was: "*The probable number of hits from a battery of mortars will be greater if the mortars are aimed independently at the target than would be the case were the mortars aimed by the parallel method.*"

In the report of the board of officers to which Lieutenant Honeycutt's paper was referred for review, a most painstaking discussion of the matter was presented. The board, claiming that Lieutenant Honeycutt's mathematical discussion of the problem had dealt only with the mean deviation of the shots from their center of impact, considered also the distance of the center of impact from the designated position of the target, as well as the distance from the designated to the true position of the target. In its discussion the board evidently assumed inability to approximate the center of impact to the target, and it took as its standard of accuracy in designating the true position of the target the work of the early Lewis depression position finder. In the course of its report the board, on page 334 of Volume 7 of the JOURNAL, states:

> It seems clear to the Board that the conditions of the problem of mortar fire demand that the projectiles of a volley be distributed over a long narrow rectangle whose average length for groups considered, with ranges from 6000 to 11,000 yards, is about eleven times its breadth. The dimensions of this rectangle are wholly independent of site, form of battery, or method of fire control.

And in its conclusions the board gives prominence to the same thought by restatement and division into two paragraphs. The board's conclusions are as follows:

> 1. The area, which should be covered by volley or other firing of mor-

tars in order to secure the maximum probability of hitting a hostile ship is a long narrow rectangle whose length is several times its breadth.

2. The dimensions of this rectangle depend upon the range of the ship and the errors of the range-and-position-finder, and are wholly independent of plan of battery, site, and local conditions.

3. Owing to the great length of this rectangle compared to its breadth, uniform dispersion in range over a greater distance than that given by the independent method is practically sufficient.

4. Parallel fire cannot be efficaciously used over the principal field of fire by any form of battery except the typical battery, and should not be used with this form when its width of front between centers of groups exceeds 40 yards; when the fire is toward a flank lateral concentration will be necessary.

5. For the principal field of fire, parallel fire with the typical battery, with exceptions just mentioned, gives range and lateral dispersion in accordance with the above requirements.

6. Satisfactory range dispersion to meet these requirements cannot be obtained by independent aiming.

7. A system of fire control by which these requirements may be fulfilled with individual mortars is possible, but such a system would embody serious complications which would endanger success, and the highest authority is against it.

8. Theories which neglect range-and-position errors in the location of the target, and deviations of center of impact from the same, are misleading and conclusions drawn therefrom are without practical value.

9. The probable number of hits upon the deck of a hostile ship will depend not only upon the shot dispersion but also upon the deviation of the center of impact from the designated position of the ship and the distance from this point to its [the ship's] true position.

10. The application of these principles to Lieutenant Honeycutt's proposition shows that the expression $Q^1 + Q^2 + \; . \; . \; . \; . \quad P^1 + P^2 +$* . . . is not generally true, and that the relation between $Q$ and $P$ depends upon circumstances * * * * *Improvements in results of range-and-position-finder will operate to the advantage*, and improvements in mortar practice to the disadvantage *of the independent method.* (The italics are the writer's.)

Professor Mansfield Merriman, after a mathematical discussion of the subject, concludes: (1) "The formulas deduced for the probability of hit under parallel fire demonstrate this to be always less than for the independent method." (2) "If inaccuracy in aim could be wholly avoided the probable number of hits under independent fire would be about four times as great as at present." (3) "For parallel fire no computations on accurate aim have been made because in this case the parallel method is at its greatest relative disadvantage."

* $P^1$, $P^2$, etc., represent the probabilities of hitting the target with one shot from an individual mortar when the mortars are laid parallel. $Q^1$, $Q^2$, etc., represent the probabilities of hitting with one shot from an individual mortar when laid independently; that is, when each mortar is laid with the appropriate azimuth and elevation for directing a shot from it to the target.

Lieutenant Honeycutt in his reply to the board's review of his original paper presented seven conclusions, of which the last four are quoted here:

4. For reasons of simplicity, or convenience, it is not objectionable, but advantageous, to use parallel fire from groups of mortars where these mortars are in close proximity to each other, as for example in the small groups of four in the typical battery.

5. No method of range-finding has yet [1897] been officially adopted which is sufficiently accurate for long ranges, such as are required for effective fire.

6. With such inaccuracy of range-finding as that represented in the Report, it would be unwise (if it could be avoided), to fire a large number of mortars depending for range on a single range-finder. The probability of hitting the ship would be very greatly increased by having a range-finder for each four groups of mortars, and firing each group with the range determined by its own range-finder; or we might use for all the mortars the mean of the several range-finder readings.

7. From the point of view of the artillerist no justification of the typical mortar battery has ever been established either by means of experimental firing or by mathematical investigation.

In 1901 experimental mortar firing was held in Portland Harbor, Maine, under the technical supervision of Captain F. S. Harlow, Artillery Corps. The results of that firing were communicated to the service in confidential form.

In 1903, after the Army and Navy coast defense maneuvers, there was additional mortar fire of which the reports were capable of use for ballistic purposes.

In 1904 Major Harlow (promoted since 1901) was called upon to look over the report of the board of officers who had reviewed Lieutenant Honeycutt's paper, and to express an opinion as to the matters therein treated. Major Whistler cooperated with Major Harlow in the work, and the result of their labors was published in Artillery Notes No. 23. The summary of conclusions, signed by Major Harlow, are as follows:

1. That converging fire is always superior to parallel fire whether we consider the percentage of hits or the probability of securing at least one hit.

2. That with all forms of batteries converging fire should be used at long range in deliberate work and parallel fire at short range or in rapid work.

3. A method which will give intermediate results can be obtained with all the ease of parallel fire, by dividing four-pit batteries into two independent batteries each completely equipped with a base-line and position finding system, *having the directing point of each battery midway between two pits.** The two pits in each battery will be fired parallel and the two batteries can be

* The italics are the writer's.

converged upon the same target. This system has the further advantage that each of the two-pit batteries may be assigned to a different target.

4. In the case of a typical four-pit battery (80 × 40 yards) the longer axis being in the direction of the principal field of fire, the line of division should coincide with the shorter axis of the battery. In a line battery of four pits the right two pits should constitute one battery and the left two pits the other. Batteries consisting of four pits in echelon should be divided as in the case of four pits in a line. The dividing line of other batteries will depend upon the local fields of fire.

5. Two-pit batteries with 50 yards between pits are best placed in column with reference to the axis of principal field of fire.

6. Four pits in line should never be fired parallel.

From the body of the report the following three extracts are taken:

Parallel fire, by its greater dispersion of the shots of a salvo, is intended to overcome in a measure the errors of position finding, predicting, etc.

* * * * * *

Since parallel fire is by far the more simple in practical fire direction, and involves less chance of the great errors which may occur in the use of a difference chart, it is manifest that we need consider converging fire only in the case where its advantages are the greatest:—in the head-on position of the ship, whatever may be its azimuth.

* * * * * *

On the whole it would seem that in slow deliberate firing, as at long range, the converging method should be used; but in order to reduce the time consumed, and lessen the chances of error due to using difference chart, convergence as to azimuth, but not as to range, may well be employed.

When, however, the delivery of as rapid a fire as possible is desired, either on account of the moral effect, or the *possibility* of securing a greater number of hits than may properly be expected, the parallel method should be used.

From the foregoing it may fairly be stated that parallel fire from a typical four-pit mortar battery was based on or justified by the following conditions or assumptions:

1. A stationary target;
2. An accuracy of fire with mortars "about half of that with guns of like caliber";
3. A firing interval of from four to ten minutes;
4. Inaccurate position finding, the original Lewis D.P.F. being assumed;
5. Very limited experimental ballistic data;
6. Inaccurate laying.

And parallel fire from the present two-pit battery is based on:

1. The possibility that, through errors of position finding, predicting, etc., being overcome by a greater dispersion of shots, there may be secured in parallel fire a greater number of hits than can properly be expected;

2. The condition that the directing point shall be midway between the two pits;

3. The greater convenience and rapidity of parallel fire.

Omitting from consideration the well thrashed out question of comparative probabilities of fire, which appears to have originated in a confusion of the dimensions of the probable rectangle with those of the target, or the probability of hitting a sinkable ship with the desirable dispersion of shots over a land target, let us see how many of the basic assumptions or conditions now obtain.

1. Stationary targets are no longer assumed.

2. The comparative accuracy of fire of mortars and guns of like caliber may be gotten roughly from a comparison of the service longitudinal probable error for mortars, 58 yards, given on page 3 of Artillery Notes No. 23, and the widths of fifty per cent zones for a twelve-inch rifle given on page 185 of the JOURNAL for September-October, 1911 (Vol. 36), from which it appears that its probable error varies from 27.5 yards at 1000 yards range to 141.5 yards at 13,000 yards range. On page 4 of Artillery Notes No. 23 it is stated that "the probable error of mortars does not change greatly for different ranges."

3. A firing interval of less than one minute with mortars is now prohibited by orders—an indication that an interval of one minute is easily practicable.

4. Range finding for mortars at long range can probably be accomplished by horizontal base; while, even on the basis of a depression position finder, two steps in advance of the original Lewis instrument have been made.

5. In ballistic data we have to-day the advantage of twenty years of target practice.

6. Whether inaccurate laying was ever a just assumption on which to found a system of fire control, it cannot be so admitted now. Each element must be perfected as far as possible, and the errors of one not left for *possible* correction by those of another. While the reviewing board styled Lieutenant Honeycutt's theory as misleading because it neglected certain errors, yet the board itself does not appear to have considered them further than to *assume* that they would be favorable, rather than unfavorable, to parallel fire.

7. While Major Harlow assumed that the directing point of a two-pit battery would be midway between the two pits, as a matter of fact the practice of correcting the fire of all

mortars in both pits by trial shots fired from one mortar in one pit, is tantamount to making that mortar the directing point. Should the trial shots be fired from an extreme right mortar in the right pit, an extreme left mortar in the left pit would have a displacement of approximately 46 yards—only four yards within the prescribed radius of the circular target, assuming an accurately ranged shot and a line of direction perpendicular to the front of the battery.

8. How can the assumed greater convenience and rapidity of parallel fire from two pits be obviated? In one of two ways: (1) frankly divide the two-pit battery into two one-pit batteries, each having its separate position finding service; or (2) provide for the firing of trial shots from a mortar in each pit and provide for each pit a separate system of correcting instruments, the actual position finding instruments only being common.

The writer is in favor of the first way, there being no reason discernible by him for controlling the fire of eight cannon of the established power and accuracy of our 12-inch mortar by a method which necessitates their firing always upon the same target.

To sum up, mortars are fired to-day according to a system founded twenty years ago on *a priori* reasoning from premises which do not now obtain, and modified ten years ago on the assumption of a condition which is in practice disregarded. The system assumes an unknown center of impact of a hypothetical mortar at the center of battery indifferently approximated to an incorrectly located target; while, in fact, upon an accurately located target we very closely approximate a determined center of impact of one mortar—frequently an extreme one—leaving the shots from all others to fall at distances from the target equal to their displacement from that one.

The errors upon an assumption of which, wisely or unwisely, the system was founded, have been eliminated, yet the system remains.

# COAST DEFENSE IN THE CIVIL WAR*

## FORT PULASKI, GEORGIA

By 1st Lieut. WALTER J. BUTTGENBACH, Coast Artillery Corps

### General Situation

The capture of the forts at Port Royal had caused the Confederates to abandon the entire coast and all coast towns south of Charleston, except Savannah, which was defended by Fort Pulaski, situated at the mouth of the Savannah River. Savannah, being the most important town south of Charleston and a point of egress for blockade runners, was the next problem that confronted the Federal commanders.

### Special Situation

General Thomas W. Sherman, commanding the Federal troops at Hilton Head, S. C., on November 29th, 1861, directed Captain Q. A. Gillmore, his chief engineer, to make an examination of Tybee Island and Fort Pulaski, in order to report upon the propriety of occupying and holding Tybee Island, and upon the practicability (and, if deemed practicable, the best method) of reducing Fort Pulaski. Captain Gillmore reported the reduction of the fort practicable with batteries of mortars and rifled guns on Big Tybee Island, giving an outline of the plans he intended to use. He also recommended the immediate occupation of Tybee Island by one regiment until the question of attempting the reduction of Fort Pulaski might be determined, thus preventing the Confederates from landing there and interfering with the construction of batteries subsequently. These recommendations were approved by General Sherman and higher authorities, and steps were taken to carry them into execution.

* See note to "Coast Defense in the Civil War, Fort Sumter, S. C (First Attack)," in Journal U. S. Artillery, March-April, 1912.

## Opposing Forces

### CONFEDERATE

Fort Pulaski, the Confederate stronghold, guarding the approaches to Savannah, had been seized by a detachment of Georgia troops on January 3rd, 1861, pursuant to instructions issued by authority of the Governor of the State of Georgia, it being ungarrisoned at the time.

The fort is situated on Cockspur Island, at the head of Tybee Roads, commands both channels of the Savannah River, and is distant from Savannah some fourteen miles. The island is a marsh, about a mile long and half a mile wide. The fort is a brick work having five sides or faces, including the gorge; is casemated on all sides; and has walls seven and a half feet thick, and twenty-five feet above high water. It mounted one tier of guns in embrasures and one in barbette. The gorge is covered by an earthen outwork (demilune) of bold relief, arranged for one tier of guns in barbette. The main work and demilune are both surrounded, and separated, by a wet ditch. Around the main work the ditch is forty-eight feet wide, and around the demilune thirty-two feet. Communication with the exterior is through the gorge into the demilune over a draw bridge, and then through one face of the demilune over the demilune ditch by another draw bridge. The scarp of the demilune and the entire counterscarp of the main work and demilune were revetted with good brick masonry.

At the time of the siege, the fort contained 48 guns,* of which 20 bore upon the opposing batteries on Tybee Island. The twenty consisted of: 5 10-inch columbiads; 5 8-inch columbiads; 4 32-pounders; 1 24-pounder Blakeley rifle; and 2 12-inch and 3 10-inch seacoast mortars, arranged as follows:

*In barbette,*

5 8-inch columbiads
4 10-inch columbiads
1 24-pounder Blakeley rifle
2 10-inch seacoast mortars

*In casemate,*

1 10-inch columbiad
4 32-pounder guns

*In batteries outside the fort,*

1 10-inch seacoast mortar
2 12-inch " mortars

* Report of Major-General Q. A. Gillmore. (See pp. 148 to 165, vol. vi, Series I, Official Records of the Union and Confederate Armies.)

The entire armament of the fort, i.e. the 48 guns above mentioned, comprised: 5 10-inch columbiads; 9 8-inch columbiads; 3 42-pounders; 3 10-inch mortars; 2 12-inch mortars; 1 24-pounder howitzer; 2 12-pounder howitzers; 1 6-pounder; 20 32-pounders; and 2 4.5-inch Blakeley rifled guns. There was a large supply of ammunition.

A complete armament for the fort would have been 140 guns.

The fort was commanded by Colonel Charles H. Olmstead, and garrisoned by five companies, of an aggregate of about 400 men.

The island on which the fort is, was surrounded by channels of deep water and the nearest approach on tolerably firm ground was on Big Tybee Island, about one to two miles distant to the south east, consisting largely of a narrow strip of shifting sands formed by wind and waves. It was thought by Confederate officers that any successful siege operations against Fort Pulaski were absolutely impracticable; so the measures adopted for adding to its strength and safety were of the most meager character.*

### FEDERAL

The principal opposing Federal work was on Big Tybee Island, consisting of a line of eleven batteries about one and a half miles long, and opposite the south east face of Fort Pulaski, the extremities of the line being about one and two miles respectively from the fort. It was intended to deliver a concentric fire upon the fort. In the early part of February additional Federal troops had landed on Tybee island and the construction of batteries had been begun. Behind the sands of Tybee Island is a mud marsh varied by ridges and hummocks of hard ground. The distance along the north shore from the landing place to the advanced batteries on the sand ridges, was about two and a half miles. Over the last mile, which is low and marshy and which was within effective range of the guns of Fort Pulaski, a causeway of fascines and brush wood had been constructed.

The armament comprised 36 pieces distributed in batteries, as follows:

1. Battery Stanton—3 13-inch mortars, distant 3400 yds. from Fort Pulaski

* General Totten, Chief Engineer, U. S. Army, also wrote: "The work could not be reduced in a month's firing with any number of guns of manageable calibers." *Battles and Leaders of the Civil War*, vol. ii, page 1.

2. Battery Grant—3 13-inch mortars, distant 3200 yds. from Fort Pulaski
3. Battery Lyon—3 10-inch columbiads, distant 3100 yds. from Fort Pulaski
4. Battery Lincoln—3 8-inch columbiads, distant 3045 yds. from Fort Pulaski
5. Battery Burnside—1 13-inch mortar, distant 2750 yds. from Fort Pulaski
6. Battery Sherman—3 13-inch mortars, distant 2650 yds. from Fort Pulaski
7. Battery Halleck—2 13-inch mortars, distant 2400 yds. from Fort Pulaski
8. Battery Scott—{3 10-inch columbiads; 1 8-inch columbiad} distant 1740 yds. from Fort Pulaski
9. Battery Sigel—{5 30-pounder Parrots; 1 48-pounder James (old 24-pdr.)} distant 1670 yds. from Fort Pulaski
10. Battery McClellan—{2 84-pounder James (old 42-pounder); 2 64-pounder James (old 32-pounder)} distant 1650 yds. from Fort Pulaski
11. Battery Totten—4 10-inch siege mortars, distant 1650 yds. from Fort Pulaski

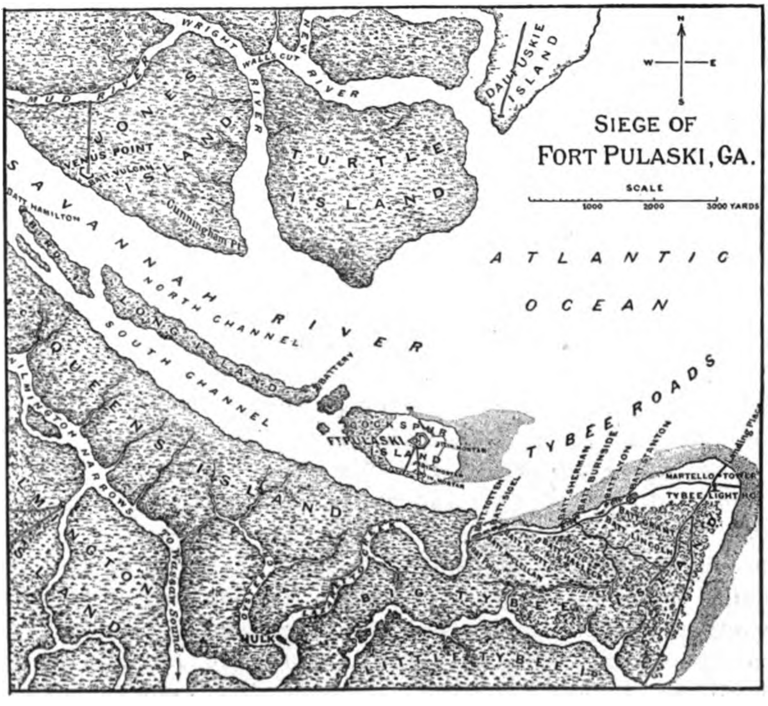
Between batteries, traverses were built. Each battery had a service magazine capable of holding a supply of powder for about two days' firing. A depot powder magazine of 3600 barrels capacity was constructed near the Martello Tower. (See map in the Atlas of *Official Records of the Union and Confederate Armies.*)

The positions selected for the five advanced batteries were artificially screened from view from the fort by almost imperceptible changes, effected little by little, in the condition and the distribution of brush wood and bushes in front. No sudden alteration in the outline of the landscape was permitted. The attitude of the garrison of Fort Pulaski was one of unsuspicion or indifference; there was no interference with the work. The work of unloading the ordnance, etc., was one of excessive toil and the labor was performed mostly at night.

The troops on Tybee Island at this time were: the 7th

Connecticut Volunteers; the 46th New York Volunteers; two companies of Volunteer Engineers; and, part of the time, two companies of the 3rd Rhode Island Volunteer Artillery. Also, a detachment of some 100 sailors served at the guns.

There were batteries erected on Jones Island as also on Bird Island, there being six guns on each; there was also a battery on Decent Island. The two former were above Fort Pulaski and the latter below.* These batteries bore no actual part in the bombardment of the fort, but were built with the idea of closing the approaches to the fort.




*Courtesy of The Century Co.* 1344

There was also a mortar battery erected on Long Island manned by two companies, this battery came into action the last day of the bombardment, but it was found to be too far away to do anything.

The ammunition supply on both sides was ample, though in some cases, as Lieut. Porter, the Ordnance Officer of the Federal forces, states, preparations were so hurried for opening

* The north point of Decent Island is seen on the map to the right of the arrow "To Wassaw Sound."

the bombardment that powder measures were improvised from vegetable tins, that columbiad shells were strapped with strips of old tents, and that fuse plugs were whittled out by hand during the night.

There were several boats belonging to the Navy but they took no part in the actual bombardment, and the Confederate gunboats after the first few days were not in evidence.

### Narrative of Events

In accordance with the plan of Captain Gillmore, the 46th New York Volunteer Infantry was sent in the early part of December, 1861, to occupy Big Tybee Island, and operations incident to investing Fort Pulaski were begun. About the middle of January, 1862, a joint expedition was organized by General Sherman and Commodore Du Pont, consisting of one regiment of infantry (48th N. Y. Vols.), two companies of New York Volunteer Engineers, two companies of the 3rd Rhode Island Heavy Artillery, with twenty guns of various calibers and accompanied by three gunboats.

These troops were to rendezvous at Daufuskie Island, where, earlier in January, three companies of the 7th Connecticut Volunteers had landed. This island was the nearest land available and suitable for a base, it being the only dry land in the vicinity, and was some four miles from Fort Pulaski. Another mixed force was sent about the same time to the south of the Savannah River to Wilmington Narrows, it being intended to cut off Fort Pulaski from all outside communication.

By the 12th of February a battery (Battery Vulcan) consisting of one 8-inch howitzer, three 30-pounder Parrotts, and two 20-pounder Parrotts, was erected on Jones Island at Venus Point; and by February 20th one on Bird Island (Battery Hamilton) consisting of one 8-inch howitzer, one 30-pounder Parrott, one 20-pounder Parrott, and three 12-pounder James rifles. These works were about four miles above the fort and on the river.

In addition, two companies of infantry with three pieces of artillery were placed on a hulk anchored in Lazaretto Creek two and a quarter miles south of the fort, to intercept communication from the direction of Wassaw Sound. But with all these preparations it was not possible to isolate Fort Pulaski absolutely—messengers frequently passed to and from the fort. Some of them, however, were captured.

On the morning of the 13th of February the Venus Point battery (Battery Vulcan) came into action, firing upon the Confederate steamer *Ida* as she came down the river. Nine shots were fired at her but she was unhurt, all shots passing astern. Captain Gillmore states in his report that not enough correction was made for the travel of the vessel. In this fire all the guns except one recoiled off their platforms. The platforms were at once enlarged to double size. The *Ida* returned to Savannah by another route. On the next day, the Confederate gunboats engaged the battery for a short time; but after one was struck, they withdrew.

On February 19th active work was begun on Big Tybee Island. The first vessel with ordnance and ordnance stores arrived from the North in Tybee Roads on February 21st. The blockade of Fort Pulaski may be said to have been effective from February 22nd on.

From February 21st to April 9th all troops on Tybee Island were engaged in building batteries, and making preparations necessary to engage the guns of Fort Pulaski.

On the afternoon of April 9th everything was in readiness to open fire. General orders were issued prescribing for each battery its point of attack, rate of fire, length of fuse, charge, and elevation.*

The mortars were to drop their projectiles within the work, while the fire of the guns was to be directed mainly against the barbette guns of the fort, and was to take the gorge and north walls in reverse. The *pan-coupé* joining the south and southeast faces was an especial target for the guns, the plan being to open a practicable breach for assault and to expose to a reverse fire the magazine in the opposite angle.

Just after sunrise on the 10th of April, Major General Hunter, Commanding the Department of the South, sent a flag by one of his aides to the fort demanding its surrender. Colonel Olmstead briefly declined to comply with the demand, stating that he was there "to defend the fort, not to surrender it."

Firing then opened up, the first shell, at 8:15 a.m., coming from Battery Halleck, situated in about the center of the line. By half past nine all batteries were in action, each mortar firing at 15-minute intervals and the guns two to three times as fast.

* See *Official Records of the Union and Confederate Armies*, Series I, vol. vi, pages 156, 157.

The enemy replied vigorously, though not very accurately, with his barbette and casemate guns. By one o'clock that afternoon it became evident that a breach would be effected in the Confederate work, unless the Federal guns should suffer from the Confederate fire. It was seen that the rifled projectiles were plowing through the scarp of the *pan-coupé* and the adjacent south east face. When the firing ceased for the night, after some nine and a half hours duration, the beginning of a breach was distinctly visible.

The 13-inch mortars were from some cause inefficient, not more than one tenth of their shells falling within the fort. In the fire two barbette guns of the fort were disabled and three of its casemate guns were silenced.

During the night two or three pieces were kept in action to prevent the Confederates' repairing any damages they had so far sustained.

Shortly after sunrise on the 11th the batteries again opened up, the fort returning the fire.

By noon, the first two casemates in the southeast face were opened their full length, shots passing through the timber blindage in the rear and reaching the magazine at the northwest angle of the fort. It was readily evident that a few hours work of this kind would clean away the scarp wall to a greater width than the small garrison could defend against assault, and preparations for storming were ordered. Meanwhile, the Federal guns were pounding at the next casemate which was fast crumbling away; and at 2 o'clock that afternoon a white flag was shown and the Confederate colors came down.

The fort surrendered, and the Federal troops took possession.

The fall of the fort caused consternation at Savannah, citizens began to send their families and property to the interior.

The Federal loss was one man killed, due to his own carelessness. The Confederate loss was one man fatally wounded and several severely wounded. Three hundred and eighty five men, including officers, were surrendered.

Sixteen of the twenty guns bearing on the Federal batteries were silenced. Not one gun of the Federal troops had been struck. It was stated that the Confederate guns were trained on a particular point and were served invariably in that direction. The men soon learned the point of attack of each gun and were warned in time to take cover when a shot was coming.

The Federal batteries during the siege fired 5275 projec-

tiles, of which 3543 were from the 20 guns and 1732 from the 16 mortars. The batteries were provided with ammunition for a week's firing, of which about one fifth was expended.

The Confederates must have had ample ammunition: General Hunter in his report states that some 40,000 lbs. of powder was surrendered.

The effect of the fire was interesting, this being the first example of the breaching power of rifled ordnance at long range. Not only were two casemates opened to a width of thirty feet, but the scarp was battered down in front of the casemate piers and an adjacent wall on each side was badly shattered, so that a few hours more firing would have doubled the width of the breach. It was found necessary in repairing the work to rebuild some 100 running feet of wall. At the close of the fight, all parapet guns except three, and every casemate gun in the southeast section of the fort from No. 7 to No. 13, including all those that could be brought upon the Federal batteries, except one, were found dismounted, the casemate walls having been breached—and in almost every instance to the top of the arch; i.e., between five and six feet in width. The moat outside was so filled up with débris that one could pass over it dry shod; the officers' quarters were torn to pieces; and bomb proof timbers were scattered in all directions and the gates to the entrance knocked off. The parapet walls on the Tybee side were gone, in many cases down to the level of the earth on the casemates; and the protection to the magazine on the northwest angle of the fort had been shot away, the entire corner of the magazine next to the passage way being gone and the powder exposed. It was said three shots had actually penetrated the chamber. It was fear of an explosion, thus momentarily threatened, that probably aided in bringing about the capitulation.

On the Federal side it was noted that four 10-inch columbiads were at the outset dismounted by their own recoil, because of having unsuitable pintles and defects in their wrought iron chassis. These with one exception were subsequently remounted and served. The mortar practice was very unsatisfactory, due to various causes, among which Captain Gillmore mentions lack of cartridge bags for the mortars, inequalities in strength of powder, defects inherent in the pieces themselves, etc.

The expenditure of ammunition in detail by the Federal Batteries was as follows:

| Battery Stanton | 1st day | 2nd day | Total |
|---|---|---|---|
| 3 13-inch mortars | 154 | 101 | 255 shells |
| Battery Grant | | | |
| 3 13-inch mortars | 181 | 101 | 282 " |
| Battery Lyon | | | |
| 3 10-inch columbiads | 140 | 181 | 321 " |
| Battery Lincoln | | | |
| 3 8-inch columbiads | 246 | 182 | 428 " |
| Battery Burnside | | | |
| 1 13-inch mortar | 81 | 74 | 155 " |
| Battery Sherman | | | |
| 3 13-inch mortars | 132 | 100 | 232 " |
| Battery Halleck | | | |
| 2 13-inch mortars | 120 | 100 | 220 " |
| Battery Scott | | | |
| 3 10-inch columbiads | 3 | 200 | 203 " |
| 1 8-inch columbiad | 179 | 119 | 298 " |
| Battery Sigel | | | |
| 1 48-pounder James | 133 | 116 | 133 shot; 116 shells |
| rifle (old 24-pdr.)<br>5 30-pounder Parrott | 150<br>517 | 584 | 150 " 1101 " |
| Battery McClellan | | | |
| 2 84-pounder James<br>(old 42-pdr.) | 181<br>20 | 9<br>187 | 190 " 207 " |
| 2 64 pounder James | 202 | 178<br>16 | 380 " 16 " |
| Battery Totten | | | |
| 4 10-inch siege mortars | 330 | 258 | 588 shells |
| Total fired from 20 guns | | | 3543 |
| Total fired from 16 mortars | | | 1732 |
| | | | 5275 |

As indicating the advance in matériel, there is presented on the following page a table of penetrations, charges, etc., as determined in this siege.

Of the Federal personnel there were no artillerymen of any experience whatever, except the detachment of sailors from the Navy who manned four of the light siege pieces in Battery Sigel on the second day of the firing. Four of the batteries were manned by the 3rd Rhode Island Volunteer Artillery, who were conversant with the manual of the piece but had never been practised in firing. All other pieces—i.e., 22 of the 36—

were served by infantry troops who had been constantly on fatigue and who received all their instruction in gunnery at such odd moments as could be spared during the week or ten days before the action.

The ultimate result of this engagement was the entire closing of the Savannah River to blockade runners, so that the naval force there employed was set free for service elsewhere.

| Kind of gun | Distance from wall | Kind and weight of projectile | Elevation, degrees | Charge, lbs. | Penetration brick wall, inches |
|---|---|---|---|---|---|
| Old 42-pounder rifled | 1650 yds. | James 84 lbs. solid | 4½ | 8 | 26 |
| Old 32-pounder rifled | 1650 yds. | James 64 lbs. solid | 4 | 6 | 20 |
| Old 24-pounder rifled | 1670 yds. | James 48 lbs. solid | 4½ | 5 | 19 |
| Parrott rifled gun | 1670 yds. | Parrott 30 lbs. solid | 4½ | 3½ | 18 |
| Columbiad (10″) S. B. | 1740 yds. | Parrott 128 lbs. solid round | 4½ | 20 | 13 |
| Columbiad ( 8″) S. B. | 1740 yds. | Parrott 68 lbs. solid round | 5 | 10 | 11 |

## Comments

1. The siege of Fort Pulaski may properly be said to mark the end of the old formal type of brick fortification, by reason of their being unable to stand against rifled artillery.
2. This is a good example of taking a work by fire effect alone, the works being rendered untenable by the fire to which they were subjected.
3. Ships took no part in the bombardment, the contest being between a fort and batteries constructed on nearby land.
4. The siege of Fort Pulaski affords an example of successful fire tactics, the Federals having assigned guns with regard to the targets to which they were assigned, and having carefully worked out the details of execution.

## Authorities

Official Records of the Union and Confederate Armies. Series I: Vol. I, pages 318-319; Vol. VI, pages 133-168; Vol. XIV, pages 320-338; Vol. LIII, pages 76, 111-114. Series II: Vol. VIII. Series IV: Vol. I; Atlas, Plate V, maps 3 and 4, and Plate CXXXIII, map 3.

Battles and Leaders of the Civil War, Vol. II, pages 1-12.

Siege and Reduction of Fort Pulaski (Gillmore).

# PROFESSIONAL NOTES

## THE RIGID DIRIGIBLES *SPIESS* AND *ZEPPELIN*

### THE FRENCH AND GERMAN AERIAL FLEETS

Translated from the French for the Journal of the U. S. Artillery by 1st Lieutenant ALBERT L. LOUSTALOT

By a rather curious coincidence, while tests were being made with the new dirigible balloon, *Spiess*, offered to the French army by its inventor, the newest *Zeppelin*, which had just come out of the builder's shops at Friedrichshafen, happened, on the 3rd of last April, to land on French soil at Lunéville, thus arousing public opinion in France and Germany. Accordingly, the moment seems particularly opportune, not only for describing the *Spiess*, but also for comparing it with the *Zeppelin*. Afterwards we shall compare the rigid with the non-rigid, which is, except in Germany, the most in use.

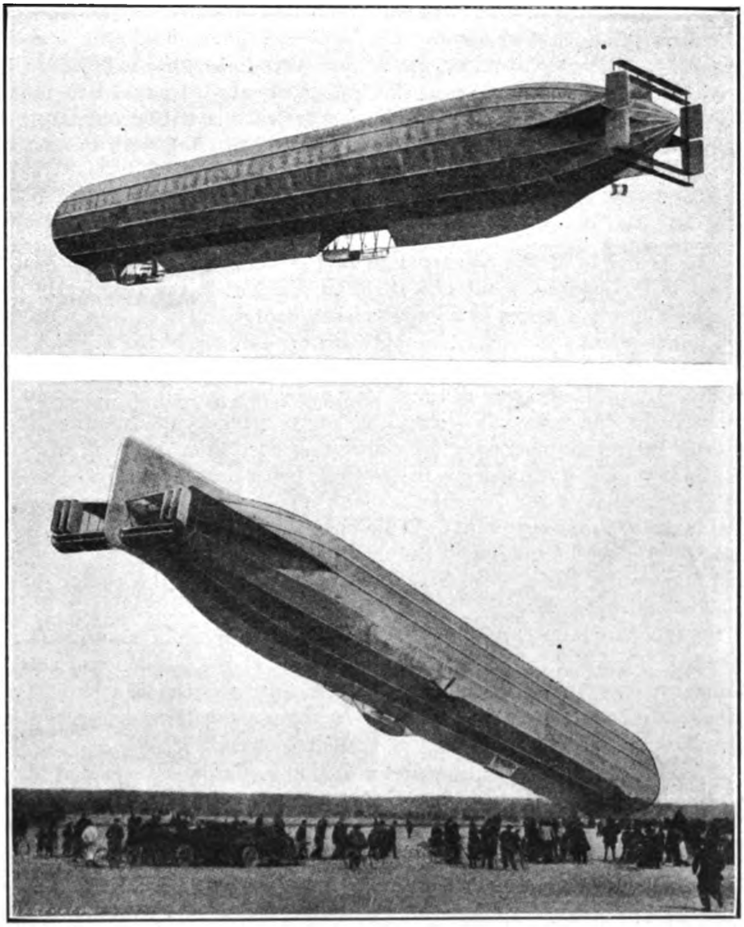
It is very important first of all to emphasize the fact that the *Spiess*, far from being an imitation of the *Zeppelin*, is a realization of an idea much prior to it. Indeed, the idea of a balloon with rigid frame and independent compartments was advanced by M. J. Spiess as early as 1873, while the earliest Zeppelin dates only from 1895. Unfortunately this Spiess idea was too long neglected and it is only to-day that the original inventor is able to see his idea realized. It is obvious, then, that, in spite of the exterior resemblance of the two balloons, there can be no question of imitation of the *Zeppelin*—a fact which we shall further demonstrate later on by a detailed description of the *Spiess*.

Before recalling the essential characteristics of the Zeppelins, which were given ten years ago in *Le Génie Civil*, we shall relate rather hurriedly the incident of the *Zeppelin IV* and the details of its unexpected visit to France.

The afternoon of April 3, 1913, the cavalry troops which were drilling on the field at Lunéville suddenly saw along the horizon the characteristic silhouette of a Zeppelin, which finally came closer and landed with the aid of the French cavalry troops. The crew consisted of four German officers and seven civilian mechanics. It was learned that this dirigible, called the *L. Z. IV*, built for the German army and having all the features of a military balloon except the armament, was being tested just prior to its acceptance by the government.

The officers and crew declared that immediately after leaving Lake Constance for a trip to Baden and Metz, the balloon ascended to an altitude of 6560 feet in order to test its climbing powers. At this altitude the wind was doubtless blowing towards the west, which was contrary to its direction near the earth, and as the clouds concealed the route, the pilot did not know that he was over French territory. When the aviators discovered where

they were they decided to land, in order to show that it was not a case of spying nor of voluntary invasion; and also, perhaps, because the balloon could not go any farther, as there was very little gasoline left and as they had lost a quantity of gas, which latter fact had forced them to throw overboard a great number of heavy objects that the balloon was carrying.



The *Spiess* in a trial flight 1345
The *Zeppelin, L. Z. IV* landing at Lunéville, April 3, 1913

The German explanation was accepted by the French authorities, who allowed the aeronauts to have sent from Strass 35,335 cubic feet of compressed hydrogen gas in order to replenish the balloon's supply. They also allowed a crew of workmen from the Zeppelin workshops to come to Lunéville to repair the balloon. One part of the metallic armature had really been damaged and one of the little compartments broken; but the repairs were very quickly made. This ease of repair is by no means one of its least merits.

However, it was necessary to lighten the weight of the balloon by leaving behind one of its rear motors. It was then allowed to return into Germany in charge of the civilian crew, while the officers returned by rail.

The German press showed some bad feeling at this occurrence which gave us a chance to examine the latest sample of the German aerial fleet.

It is certain that the essential characteristics are well known, and the improvements of the system have not changed it so much that we can't refer to the descriptions that we gave of it in *Le Génie Civil* in 1903, 1907, and 1909. The secrecy with which the last models are surrounded shows, however, that much importance is attached to the improvements introduced to make it a very powerful engine of war. A long experience in fitting out larger and larger balloons certainly enables them to-day to bring the work to a remarkable degree of perfection.

### THE ZEPPELIN SYSTEM

The principle of the construction of the Zeppelins is well known. It consists in the establishment of a skeleton which is in itself perfectly rigid, and which forms a series of compartments containing a certain number of small independent balloons. The outward appearance of the balloon is not affected in any way by the pressure of the gas inside. The cells may be incompletely inflated, some of them may even be emptied as the result of a tear, without the balloon's losing any of its navigating qualities; it still possesses the means necessary for continuing its route, provided, of course, it contains enough hydrogen gas to assure its being held in the air.

The rigidity of the Zeppelin balloon is obtained by means of a light skeleton with aluminum joints. This skeleton is composed of longitudinal ribs kept in place by polygonal frames of twenty-four sides, and these polygonal frames are stiffened by steel rods radiating from the center like the wheels of a bicycle.

To this framework is attached a keel, or large piece of wood, triangular in shape. This keel reinforces the central part of the balloon and acts as a passageway in establishing easy communication between the two baskets. In the central part of this keel is also the main cabin for passengers similar to those on the dirigibles designed especially ro carry tourists.

We know that in order to assure stability, a plan was devised of furnishing these dirigibles with a fixed vane (*empennage*), and later with systems of movable planes analagous to the fins of submarine boats. When the balloon moves forward, the action of the air striking these plane surfaces causes a vertical pull which is positive or negative, depending on the inclination of the planes, and this pull causes vertical displacements without either losing gas or throwing out ballast.

It might be said that it was on the *Lebaudy* of 1903 that the rear vanes (*empennages*) were first used, and that the movable stabilizing planes, invented by Colonel Renard, were used in the French dirigibles long before Count Zeppelin made use of them in 1906-1907.

The dirigible which landed at Lunéville is at least 485 feet long and has a diameter of 46 feet and a volume of 706,700 cubic feet (for gas). Its two baskets carry, in addition to a numerous crew, three motors of a total strength of 600 horsepower. The front motor drives two two-bladed propellers on parallel shafts by a direct shaft and bevel gear transmission. In the same way the two rear motors drive a pair of propellers with four blades; and, by

means of a quadruple clutch, a person can operate one of the propellers by either one of the motors or one propeller by the two motors.

The dirigible carries a complete installation of wireless telegraphy. As to its armament, that was not installed; but it is known that it is to consist of a certain number of machine guns in the baskets and on a platform on top of the balloon from which it will be possible to fire on any airship that may try to attack it from above. For this purpose, to the rear of the forward basket, a passageway provided with a ladder pierces the keel between two sectional balloons and opens upon a little platform 9.84 feet square.

### THE SPIESS SYSTEM

As we stated at the commencement of this article, the Spiess idea dates back to 1873, but the inventor had to wait forty years to find himself in a position to carry out his idea, because the French have believed until now in the non-rigid system, remarkable samples of which, such as the *Lebaudy, Patrie, Clément-Bayard, Ville-de-Paris, Colonel-Renard, Zodiac, Astra*, etc., where created by French industry. M. Spiess, with meritorious persistence, has succeeded, however, with the help of the Zodiac Society in constructing his dirigible, and has offered it to the French army—an act which does him credit.

The dirigible which is now being tested was planned principally for demonstration, and without doubt does not have a sufficient cubic capacity to carry out completely its military rôle, when we consider that a rigid balloon, on account of the dead weight of its frame, ought to be larger than a non-rigid balloon of the same speed and same sphere of action.

The skeleton of the *Spiess* is made up of longitudinal ribs and polygonal frames of fourteen sides; but this light framework, instead of being of metal is composed of hollow pieces consisting of four ¼ in. to ½ in. strips of wood wrapped with canvas bands well glued together. In this way is secured material that is very light, resistant, and elastic, this latter being a very important quality when the framework is liable to receive shocks. The advantages of wood in the construction of aeroplane frames is very well known, and there is no reason why the use of wood in the framework of dirigibles should not offer the same advantages. The efforts of M. Spiess have not failed to attract attention, even in Germany, where the firm of Schutte-Lanz recently began the construction of four rigid, wooden-frame dirigibles of a capacity of 848,000 cubic feet each.

The frames in the Spiess skeleton are 27.86 feet apart, forming eleven compartments in which are placed the small gas balloons. These smaller balloons have each a capacity of 42,400 cubic feet and are kept in place by a netting in the cylindrical part which forms the body of the dirigible. The hull is terminated by ogival cones, the rear cone being a little more pointed than the front one.

At first, the length of the hull was to be 341.2 feet; but it was afterwards increased to 370.7 feet by the addition of a supplementary cell. With a maximum diameter of 42.6 feet its capacity is 16,742 cubic yards, a little bit small perhaps, in view of its dead weight.

In spite of this, they have been able to place in it ten reservoirs for the water ballast, eight of them on the balloon and two in the baskets. These reservoirs have a capacity of 3307 pounds. The valves of these reservoirs are regulated by wires which run up to a little board near the hand of the pilot. On this same board are grouped also the handles to the valves of the

different small balloons. These valves work automatically when the pressure of the gas passes the safe limit.

Two sets of planes are used for rudders, one set to guide the balloon horizontally and the other to guide it vertically. The rudders for guiding in direction (horizontally) are formed by two pairs of vertical planes, a pair being on each side of the stern and arranged so that one plane of each pair is located directly above the other one of the pair. Each one of these planes measures 452 square feet.

The two sets of four horizontal planes each which serve as rudders for guiding in altitude (vertically), are the upper and lower sides of a rectangle of which the vertical sides are the rudders for direction. Each plane is 26.24 feet long and 3.28 feet wide, the whole system of horizontal planes thus presenting a surface of 689 square feet. Their supporting framework is attached to that of the two fins and of the two triangular keels, the whole forming the fixed vane (*empennage*).

The framework of the hull is built in with that of a long keel of triangular section which runs along the central section of the hull, to the curve of which it conforms for the purpose of stiffening the rear cone. This keel, which is 210 feet long and covered with cloth, serves as a passageway between the two baskets, which are situated on a slightly lower level. The total height of the balloon, including the baskets, is 55.76 feet.

Each one of the baskets has installed in it a six-cylinder (vertical) 200-horsepower Chenu motor, thus giving a total of 400-horsepower. These motors are air cooled by two ventilators.

The balloon is driven forward by two pairs of two-bladed wooden propellers of 13-foot diameter and 23.5-inch pitch, kept in place by projecting frames at about the axis of thrust on the two sides of the balloon. The shaft of the propeller is supported by three bearings, one of them being ball-bearings and the two other smooth-bearings. The cog transmission has an oblique shaft of 24.6 feet, mounted *a la cardan*.

Cables running lengthwise and extending the whole length of the hull stiffen the frame by binding the elements together; they meet at the mooring ring used in anchoring the balloon.

The first trips of this dirigible on April 30th and May 2d afforded proof of its great stability and gave every reason for believing that the final outcome will be successful.

### The French and German Aerial Fleets

Because a rigid dirigible has just been constructed in France must we conclude that a complete change has come about among our responsible authorities, and that, after having adopted the non-rigid balloon exclusively, these authorities have recognized in the rigid system such advantages that it becomes necessary to change our policy? We do not think so. It is possible that we should give a certain place in our aerial fleet to the rigid balloon, but the objections that have been advanced against it have not lost all their force; and, moreover, for the same reason that a naval fleet is not composed exclusively of dreadnoughts, an aerial fleet may very well include balloons of different kinds appropriate for the different uses to which they are put. Germany herself has not failed to recognize this. In addition to her fine squadron of Zeppelins she possesses some non-rigid balloons of the *Parseval* type, and if the Gross-Basenach balloons which have figured among the military balloons have disappeared on account of accidents, it is only for the

present. The three types of balloons took part in the grand maneuvers together; and, so far as we know, the Zeppelins did not show themselves superior to the other two types. Indeed, the large rigid balloons seemed reserved for strategic reconnaissance on a large scale, where their sphere of action and their speed might present some advantages.

If it is recognized that these advantages balance the disadvantages of the non-rigid system, we also have among us some engineers capable of constructing rigid dirigibles; and it is a somewhat childish fear that certain newspapers of Germany expressed when they deplored the fact that the Lunéville incident had laid bare to us the secrets of the *Zeppelin* and had permitted us to construct some balloons like it. By not carrying out that plan until now, we have not necessarily admitted that we have been unable to do so, but simply that we have obeyed another teaching.

### THE FRENCH TENDENCIES AND THE CONSEQUENCES OF A LULL IN THE DEVELOPMENT OF OUR AERIAL FLEET

If the aerial fleet of the German army is to-day superior to ours, it is not because rigid dirigibles are employed in Germany and because we have none, but because the development of our aerial squadrons have suffered from a deplorable cessation of work, the awful consequences of which it will be difficult to overcome. France, where the dirigible balloon originated, in order to retain her mastery of the air, had only to make use of a little perserverance in the prosecution of her plans, when, about 1910, after having commenced the construction of some of the best balloons of that time, she was seized with uncertainty, suddenly hesitated and halted the execution of a carefully laid program and cancelled the orders she had already given for the construction of balloons.

What had taken place to justify that change of policy? We must look for the cause of it in the appearance of the first aeroplanes really worthy of the name and in the hopes to which they suddenly gave rise. The "Circuit of the East" in 1910 had been a revelation in that respect. These rapid aerial vessels had, up to that time, been considered only as instruments of a perilous and useless sport, and suddenly their military importance came into prominence. At that time many people thought that the dirigibles would disappear before the aeroplane.

In addition to its high price, one objection to the dirigible at first was its low speed, which did not enable it to struggle against relatively moderate winds, it being put out of action too often. It was criticised on account of its enormous volume and on account of the difficulties to be overcome in replenishing the supply of hydrogen or in chance landings, where, not being amphibious, it was at the mercy of strong winds as soon as it had touched the earth. This latter fact would make it necessary to construct numerous shelters along the route.

The aeroplane, on the other hand, lacking in bulk, always ready, easy for one man to manage, seems to defy the most violent winds, thanks to its speed. Its small cost makes possible having it in large numbers. It is only a squadron of grains of dust; but what can large, gaseous balloons which the smallest projectile can burst, accomplish against such dust in clouds of countless grains?

People did not ask if the new-comers, hardly born, had already been perfected; if their architecture had taken some definite form; if they offered the necessary safety while moving through the air; if they had the stability;

finally, if they already had the tried-out qualities that were required in an instrument of war.

Aeroplanes were, at that time and still are, far from possessing the essential qualities which would permit them to replace balloons in all cases. They have the speed necessary to make a rapid reconnaissance towards some one, well-defined point; but they have neither the carrying capacity nor the large sphere of action necessary in grand strategic reconnaissances. The physical effort required in making a reconnaissance of several hours into the enemy's country limits its action, as the observer, confined in his narrow seat, has not the necessary liberty of movement in an operation of long duration for taking down notes and examining maps; indeed it is difficult, at least up to the present time, to install in an efficient way in an aeroplane either the light projectors for night reconnaissance or the apparatus for wireless telegraphy which would permit constant communication between it and the staff, of which it is a necessary part.

The dirigible, on the contrary, possesses the qualities which are the opposites of these defects.

No doubt the aeroplane will be perfected. Every day it more nearly approaches the ideal. When this ideal will have been attained the dirigible may disappear; but until that time it would be as great a folly for a country to deprive itself of the use of dirigibles as it would be for a country to suspend the construction of battleships because it had torpedoboats.

The heads of the department of military aeronautics were convinced of these truths; but they did not succeed in making others high up in authority perceive them, so work on the new dirigibles already ordered was stopped. With such a condition of affairs the least delay is hard to overcome. The French manufacturers, during all this period of uncertainty, have had only a few orders from foreign countries and occasional tests of aerial tourists to keep their factories busy. These conditions were little conducive to perfection of technique: progress is the result of continuous effort and of successive transformations, in which experience develops and perfects little by little.

About the time that the mistake was recognized, it was also understood that the rôle imposed on dirigibles required that they have considerable volume; it would be necessary, by some bold initiative, to pass quickly from the balloons of from 100,000 to 140,000 cubic feet of yesterday to those of 500,000 and 700,000 cubic feet of to-morrow. But people were afraid of such a step into a subject then unknown, so they stopped at the halfway mark; it is for this reason that our aerial fleet is still encumbered with balloons of 200,000 cubic feet, provided with a motive force of only 150 horsepower and incapable of making more than 30 miles an hour.

Very fortunately we have taken up the subject again. At present we have put into service five dirigibles of the cruiser class of 300,000 cubic feet capacity, furnished with 250 horse-power motors and capable of running 34 miles an hour; such as *Adjudant-Vincenot*, *Adjudant-Réau*, the *Lieutenant-Chauré*, the *Dupuy-de-Lôme* and also the *Commandant-Coutelle*, which was constructed by the Zodiac Society and which went out for the first time at Saint-Cyr on May 8.

In spite of its small capacity of 230,000 cubic feet, the scout dirigible *Fleurus*, which has just finished its trials, deserves special mention, because with a motor of only 150 horse-power it was able to attain a speed of 36 miles an hour. Studied in its minutest details by the officers of Chalais-Meudon, where it was constructed, it amply makes up, by the perfection of its form and

the waterproof qualities of its covering, for the inconveniences of its lack of size.

Finally, let us say that seven large military dirigibles of the cruiser type and four others for civilian use, are to be constructed in 1913 and will be followed immediately by four balloons of the type of the *Fleurus*, *Bayard-Clément*, *Astra*, and *Zodiac*.

COMPARISON OF THE GERMAN AND FRENCH AERIAL FLEETS

We are making every effort to make up for the lost time, but we must admit that this little period of hesitation sufficed for our neighbors to make a considerable advance. In spite of numerous mistakes and terrible set-backs, their perseverance has gotten the better of their luck, and to-day they possess an aerial fleet that may be called powerful on account of both the number and the power of its units as well as on account of the extent of its means of replenishing the hydrogen supply, and of the methodical organization of about twenty hangars where these dirigibles find protection and refuge.

M. René Chassériaud has collected, in a table that we have borrowed from him, whatever information is available as to the German fleet, from which we can get an accurate comparison of the means of aerial navigation in France and in Germany at the beginning of 1913. To the units that are purely military have been added the civilian balloons which in time of war would be turned into military balloons, and the addition of these balloons is of the greatest importance in Germany, where tourist socities are exploiting balloons of capacities of from 600,000 to 700,000 cubic feet. The Gross-Basenachs have disappeared from this list as they were all destroyed by different accidents; one of them, however, after being repaired will be used in the park at Metz. The *Zeppelin IV*, made famous by the Lunéville incident, does not figure in the list either, but it may be considered as apt to be called back into the service. Finally, the orders placed and the construction undertaken just about equals that of France, so that the numerical difference will not change.

If we consider only numbers, the two fleets do not present any great differences; but such is not the case, if we consider tonnage and motive power, which really sum up the essential military qualities and are important factors of speed and sphere of action.

Now if we compare the tonnage and motive power, the four large French cruisers of 318,000 cubic feet capacity the *Adjudant-Vincenot*, the *Adjudant-Réau*, the *Lieutenant-Chauré*, and the *Dupuy-de-Lôme*, may be considered as excellent units, reaching a speed of 31 miles an hour. To those may be added the *Fleurus*, which attains 36 miles an hour. On the *Commandant-Coutelle*, of 318,000 cubic feet capacity, the motive power has been increased to 380 horsepower. Although the speed reached is not known exactly, we do know that an appreciable gain has been made. Anyway, increasing the power means an increase in the amount of combustible used and consequently a decrease in the sphere of action, unless it is decided to enlarge the balloon. The medium size dirigibles of a capacity of from 318,000 to 353,350 cubic feet may then be considered excellent vessels, provided the fleet be filled up with units much more powerful, such as those now being constructed of 706,700 cubic feet capacity.

In addition to those of the large cruiser class that we have just enumerated, the French aerial fleet has also a small number of the scout class capable of going about 31 miles, such as the *Selle-de-Beauchamp*. There are still

| Home Stations | Names of the Dirigibles* | Date and type† | Cubic capacity, cubic feet | Length, feet | Diameter, feet | Horse-power | Speed, miles per hour |
|---|---|---|---|---|---|---|---|
| | FRENCH DIRIGIBLES | | | | | | |
| Toul | *Adjudant-Vincenot* | 1911 S | 318,000 | 292 | 42 | 200 | 34 |
| Verdun | *Adjudant-Réau* | 1911 S | 316,000 | 285 | 46 | 240 | 34 |
| Maubeuge | *Dupuy-de-Lôme* | 1912 S | 318,000 | 292 | 42 | 250 | 34 |
| | *Selle-de-Beauchamp* | 1911 SR | 282,000 | 292 | 48 | 150 | 31 |
| Saint-Cyr | *Fleurus* | 1912 S | 230,000 | 253 | 41 | 160 | 36 |
| | *Le Temps* | 1911 S | 88,000 | 164 | 31 | 70 | 31 |
| | *Zodiac No. 3* | 1909 S | 50,500 | 138 | 27 | 40 | 28 |
| Epinal | *Capitaine Ferber* | 1911 S | 212,000 | 249 | 42.5 | 140 | 34 |
| | *Commandant-Coutelle* | 1912 S | 318,000 | — | — | 380 | — |
| Chalons | *Capitaine-Marchal* | 1911 SR | 265,500 | 277 | 42.5 | 150 | 29 |
| Issy | *Lieutenant-Chauré* | 1911 S | 316,000 | 285 | 46 | 240 | 34 |
| | *Tansaérien* | 1912 S | 318,000 | 249 | 47.5 | 300 | 34 |
| | *Conté* | 1912 S | 233,000 | 203 | 39.5 | 150 | 31 |
| | *Colonel-Renard* | 1910 S | 148,500 | 206 | 36 | 100 | 31 |
| | *Astra-Torrès* | 1911 S | 56,500 | 156 | 26 | 55 | 31 |
| Meudon | *Lebaudy No. 4* | 1911 SR | 116,500 | 200 | 34.5 | 70 | 28 |
| | *Liberté* | 1909 SR | 169,500 | 235 | 42.5 | 120 | — |
| Lucerne | *Ville-de-Lucerne* | 1909 S | 157,200 | 197 | 42.5 | 100 | 27.5 |
| On trial | *Spiess* | 1912 R | 452,300 | — | 42.5 | 400 | — |
| | GERMAN DIRIGIBLES | | | | | | |
| Metz | Z-1 | 1912 R | 424,000 | 413 | 39.5 | 230 | 36 |
| | P-1 | 1908 S | 141,300 | 197 | 34.5 | 85 | 32 |
| Hambourg | L-1 | 1912 R | 777,400 | 524 | 49 | 510 | 51.9 |
| | Victoria-Louise | 1912 R | 660,700 | 484 | 46 | 450 | 49.7 |
| Bitterfeld | PL-1 | 1908 S | 113,000 | 197 | 28 | 85 | 28 |
| | PL-10 | 1912 S | 63,600 | 148 | 29.5 | 100 | 31 |
| | Clouth | 1909 S | 65,000 | 138 | 31 | 50 | 19.8 |
| Berlin | Z-3 | 1912 R | 706,700 | 489 | 46 | 510 | 49.7 |
| | P-3 | 1911 S | 353,350 | 282 | 49 | 400 | 42 |
| | R-2 | 1910 SR | 63,250 | 151 | 24 | 75 | 24 |
| | R-3 | 1912 SR | 139,900 | 213 | 36 | 120 | 32 |
| | PL-6 | 1910 S | 265,000 | 223 | 49 | 220 | 32 |
| | PL-9 | 1911 S | 63,600 | 148 | 29.5 | 50 | 28.9 |
| | PL-12 | 1912 S | 284,500 | 230 | 49 | 220 | 37 |
| | Suchard | 1911 S | 413,500 | 249 | 54 | 220 | 28 |
| Potsdam | Hansa | 1912 R | 669,700 | 484 | 46 | 450 | 49.7 |
| Cologne | Z-2 | 1911 R | 609,500 | 459 | 46 | 450 | 47.8 |
| | P-2 | 1912 S | 284,500 | 262 | 46 | 300 | 39 |
| Koenigsberg | P-4 | 1912 S | 353,350 | 282 | 49 | 400 | 42 |
| Biesdorf near Berlin | Siemens-Schuckert | 1911 S | 530,000 | — | 46 | 650 | 46 |

* Z, Zeppelin; P, Parseval; R, Ruthenberg; L, PL, German naval dirigibles.
†S, non-rigid; R, rigid; SR, semi-rigid.

some others that could do good service in spite of their slow speed, but we should take out all those that have, by their age, become entitled to be placed in the reserve.

In Germany, while bearing in mind that the same reasons would eliminate some balloons of lesser speed or more ancient date, we find four of them that can make 31 miles an hour, while the others can make from 36 to 50 miles an hour. The naval dirigible *L. I.*, put into service in 1912, even reaches a speed of 52 miles, and these large balloons of the cruiser class can travel 600 miles.

To sum up, the gross cubic capacity of the French balloons is 4,320,764 feet and of the German balloons 6,969,829. It is true that, in the case of rigid balloons, in order to have the useful volume for purposes of comparison, we should deduct about one-third as taken up for floating of the framework. When this is done, the Germans have a useful capacity of 5,653,600 cubic feet, and the disproportion is still large. Moreover, as the activity of the German factories is not being reduced, we may conclude that the lead of our neighbors will be maintained. However, the new French constructions consisting mainly of units of 706,700 cubic feet, we may hope that at least the inferiority of speed will be overcome in 1914.

### THE TWO RIVAL SYSTEMS: RIGID AND NON-RIGID BALLOONS

If from all that has been said, there results an evident superiority of the German balloons, it is due them that we attribute it to the spirit of perseverance and consistency that has been shown throughout the building up of their fleet, and to the concentration of their effort to secure great speed and a large radius of action.

We are of the opinion that success is independent of the principle adopted in construction; so much so that alongside of the rigid Zeppelins, we find in Germany some semi-rigids, such as the Gross and the Ruthenbergs, and some non-rigids such as the Parsevals, of each of which the volume is not more than 353,350 cubic feet, but which reach a speed of 39 and even 42 miles per hour. To do this it was necessary to run the motive power up to 400 horsepower.

In spite of all the talk over the Zeppelins, in spite of the widespread discussion of several certainly remarkable flights, we are permitted to ask the question as to whether or not the rigid construction offers such advantages that it would be justifiable to abandon the non-rigid balloons whose forms are maintained solely by interior pressure.

The rigid construction permits considerable gain of volume by lengthening alone, without increase of diameter, and consequently without any increase of the resistance of the air when the balloon goes forward. But if we remember that one-third of the volume and of the ascending power which results from it, is absorbed by carrying the dead weight of the framework, we can see that a non-rigid balloon of from 494,690 to 530,025 cubic feet would have a useful capacity equivalent to that of a rigid of 706,700 cubic feet, and that a non-rigid of 706,700 would be superior to it in this respect. The construction of a non-rigid of 706,700 cubic feet is possible; there even exists a system of construction, which according to our mind has not received enough attention, but which is capable of giving to the hull of the non-rigid an exceptional invariability of form due to certain interior connections; this is the system Torrès-Quevedo.

Whether we are discussing a Zeppelin, a Schütte-Lanz or a Spiess, the

rigid dirigible presents only one advantage; but that is a military advantage of the greatest importance—the localizing of damage which results from the balloons being made up of independent cells. It may be admitted that, if a projectile strikes one of the cells and puts that cell out of service, it will be possible for the crippled balloon to retain its original form and still to be able to hold gas and continue its journey. Yet it must also be admitted that at that moment it must dispose of enough ballast to make up for the loss of ascending power, and that opportunity will not occur if the balloon has already made a long journey or has ascended to a high altitude. The different incidents of trips of the Zeppelins, and in particular the Lunéville incident, show that we must not count too surely on such chance: more often the dirigible will be forced to land, and the enemy's point will have been won.

Whatever the advantages we concede to the rigid dirigible, by its very nature, on the other hand, it presents obvious inconveniences. These inconveniences result from the frailty of its framework and from the impossibility, by letting out gas, of decreasing the volume of the balloon exposed to a storm because of which it has to land. Constructed to float around in the air, the dirigible is in a bad way every time it is forced to come down to earth and stay on the ground. It is built to go out of its hangar and to come back into it without stopping. So well is this fact appreciated in Germany that they have multiplied the hangars for dirigibles, and these hangars form a veritable line of stopping places along the whole frontier.

The story of the frequent accidents that have happened to the Zeppelins is instructive. Without stopping to discuss the simple mishaps incident to use, we know that since 1906 nine Zeppelins have been destroyed; and if two of these accidents were due to explosions, the others resulted solely from the frailty of the framework, which the least shock demolishes completely.

The first accident of this kind was on January 22, 1906. In the second accident, December 15, 1907, the dirigible was in its floating hangar at Friedrichshafen. A sudden storm blew the wall of the hangar against the sides of the balloon hard enough to smash them.

Another model, still larger—446 feet in length, 42.5 feet in diameter, and 530,025 cubic feet in volume—was immediately constructed; but it lasted scarcely three months. This balloon left for Mayence on August 3, 1908. On the return trip it had to struggle against a terrible wind. Soon an accident forced it to land at Echterdingen; but a storm struck it and dragged it around, in spite of a number of soldiers who were surrounding it. Some of the small gas cells were torn, and for some reason or other not known, a flame burst out in the front part of the balloon and an explosion destroyed it.

That was only an accident; but, after the hopes that had been raised by its trip of 372 miles, all Germany felt itself struck as if by a public catastrophe. In a moment of great enthusiam more than 7,500,000 francs were gathered by public subscription. At the same time, the German government gave to the Zeppelin class of balloons a definite place in its war matériel and laid the foundation of the new organization of its aerial fleet.

For a long time Count Zeppelin had been dreaming of setting out from Manzell, his new point of departure, and of going all the way to Berlin where he proposed to take part in the Emperior's review. The first attempt took place on May 28, 1909. The crew consisted of eight persons. It carried 4400 pounds of gasoline and 770 pounds of oil, and it spite of the beating rain it passed without stopping over Nuremberg, Bayreuth, Leipzig, and Bitterfeld.

The balloon had gone 348 miles without landing when suddenly, driven by a wind from the north-west, it was seen to turn about and quickly seek shelter. On May 31 it reached Stuttgart, but it had no more gasoline and had to land at Echterdingen, a section of the country decidedly fatal to dirigibles, for the balloon by some false maneuver demolished its front part by running into a pear tree. However, it had made 603 miles without stopping. This accident showed how the damage, localized by means of the independent cells, may be easily repaired with the tools at hand. The three front cells of the balloon were cut off and this front part was covered with a piece of cloth; and on June 1, twenty-four hours after the accident, the balloon was slowly setting out again to go back to its hangar at Manzell, which it reached on June 2.

A short while after, on August 27, with the *Zeppelin III*, Count Zeppelin renewed his attempt. The breaking of a propeller forced him to land at Urtheim; with some trouble they reached Nuremberg and finally they got to the drill-grounds of Berlin-Tempelhof. But on the return trip one of the propeller blades come loose and broke one of the gas compartments. It was necessary to land and replace the broken cell before starting again to reach the point of departure, where the balloon arrived on September 2. It would not be like that in the enemy's country in time of war.

But that is not the last misfortune to happen to the Zeppelins. On October 25, 1910, the *Z II*, coming back from Cologne, stops on account of disabled machinery. A temporary camp is established at Limbourg, but a storm breaks its anchor lines, pulls the balloon out of the hands of the soldiers who are holding it and drags it along for twelve miles, and at Weilburg the unlucky dirigible is wrecked on the walls of a hotel, which it covers with its debris.

In the meantime the Rhénane Society had been founded in order to exploit a magnificent dirigible, the *Deutschland*, and to conduct tourist excursions. On June 28, 1910, having aboard numerous representatives of the German press, the balloon sets out from Düsseldorf in a rather strong wind. For several reasons it goes up 3936 feet while losing much gas, and its ballast is then not sufficient to check a violent descent, which takes place, in spite of the maneuvering of the powerless balancing planes: the *Deutschland* falls on some trees in the forest of Teutobourg. Fortunately the trees break the fall, and the people are gotten out of this critical position without any accidents; but the balloon is out of service.

A new dirigible, 472 feet long and of great motive power, carrying two motors of 130 horsepower and one of 125, is no more successful than the others. September 14, 1910, it is destroyed by an explosion in its hangar at Baden.

This relative frequency of explosions deserves some consideration and we may state that the system itself favors these accidents. There is between the outer cover and the small elementary balloons closed spaces where the least escape of hydrogen—and there always is an escape of hydrogen—forms a detonating mixture; afterwards, all that is needed to cause the catastrophe is some little casual circumstance. The material of the covering is not stretched and there may be developed between this material or somewhere on the framework a rubbing of some sort that would develop a little bit of electricity and cause a spark. The cases where the so-called spontaneous explosions have occurred are too poorly explained for us to try to give a definite explanation of the phenomenon, but the one that we give is plausible.

The two accidents that remain to be cited are particularly characteristic, because they show that to be saved, it is not sufficient alone that a Zeppelin should be near a hangar: it is also necessary that it be able to enter the hangar. If there is a violent wind, or if the wind is not blowing exactly along the axis of the hangar, the operation of entering is almost impossible: the balloon is blown over against the wall of the hangar and is deformed and broken. The situation is no less dangerous when the balloon is taken out; because, as soon as any considerable portion of the balloon is outside of the hangar, this part is exposed to the wind and the hull is bent into two parts.

The *Schwaben*, after 229 successful ascents, left Frankfort-on-the-Main June 28, 1912, and had reached Düsseldorf, when a violent wind blowing across the entrance to the hangar forced the balloon to be camped outside to wait for calmer weather. According to custom, the balloon was anchored with its front into the wind, the crew aboard and ready to set out in case it was necessary. The balloon was struck by an irregular wind; perhaps it brushed against some obstacle—anyway, a terrible explosion destroyed it and wounded forty-one persons.

Under similar circumstances one of the finest balloons of the German navy, the *Z I*, which had just made a twenty hour trip, had to land at Carlsruhe on account of a break in the machinery. Just as in the case of the *Schwaben*, the wind interfered with the maneuvering and prevented its entrance into the hangar. They had to anchor the balloon in open air. Suddenly an awful storm struck the lower part of the balloon, tore out the anchor ropes, broke up everything, and scattered the contents all over the ground.

No exact conclusions can be drawn from this long list of accidents, for the non-rigid balloons have had accidents just as serious.

We cannot forget the awful flight of the *Patrie* and the terrible fall of the *République* after one blade of the propeller had broken the covering of the balloon. The first Lebaudys had accidents also, and in Germany the Gross-Basenachs and the Parsevals have to their account a few misfortunes; but the number in this case cannot be compared with the long list of accidents to the rigid dirigibles.

Besides, if we notice that the most characteristic accidents of the Zeppelin are due to the extreme frailty of its armature, we can understand why a whole school persists in believing that the rigid balloons do not offer an exclusive and ideal solution of the problem, and that even in the case of the military dirigibles we may attain the purpose for which they were designed with non-rigid balloons, which are smaller for the same volume, more manageable, and less costly.

If we are a little premature in giving a precise and definite answer to all these questions, the putting into service of the next French dirigibles of 706,700 cubic feet cannot fail to bring out the exact points where we are now in error.—*Le Génie Civil.*

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## INCREASE OF CALIBER OF PRIMARY NAVAL ARMAMENT

Although public opinion in Germany, preoccupied as it is with the impending enormous increase in the army, shows less interest in the navy now than it has shown in recent years, yet the official journals continue to

give the navy prominence in discussion and in reports of progress, projected or realized.

Thus it is that the *Artilleristische Monatshefte* for March, 1913, has presented an article (reproduced in many reviews—in particular in the French supplement for May of the *Internationale Revue über die gesammten Aremeen und Flotten*) on the subject of the increase of caliber of primary naval armament and the increase of displacement which is an inevitable consequence thereof.

This article affords, moreover, another opportunity—which the *Artilleristische Monatshefte* never lets pass—for singing the praises of Krupp matériel, the excellence of which is an inviolable dogma. But, however that may be, it very clearly sets forth the present status of the question.

The contest between gun and armor dates from the Crimean War, and the rivalry has given rise to a series of technical inventions and wonderful improvements of which the end is not yet. As is well known, the German navy has always proceeded with great caution in the matter of increase of caliber; and such a cousre was possible for it because of the incomparable quality of Krupp guns: it could leave to other navies the burden of costly and hazardous experiments, while at the same time it kept its place in the van of progress.

In the armament of German ships of the line of the *Helgoland* class (already complete) and of the *Kaiser* class (in course of completion), we have to-day reached a caliber of twelve inches and a length of fifty calibers, or fifty feet; while the English navy abandoned the 12-inch caliber in 1909, at the time of equipping the super-dreadnought *Orion*, when it adopted a 13.5-inch gun of 45 calibers. Accordingly, those ships will have a displacement of 25,000 tons.

England has always striven to surpass other nations in naval artillery, and from that has resulted incessant experimentation and an insatiable mania for records. These efforts of England's have arisen in part from the fact that it has been recognized that the wire-wrapped system of gun construction is not the equal of the hooped system employed in other countries, and notably in Germany; although ill-informed persons in England imagine that after long years of work and endeavor they have in that country surpassed the German product. On the contrary, however, the Krupp gun has been quietly and methodically developed along sound lines, and increases of caliber can be effected without essential modification of the system. Owing to the high initial velocity of Krupp guns, which impart to the projectile very high kinetic energy per pound of metal in the gun, it has up to now been believed in Germany that the 12-inch, fifty caliber gun is fully equal to the English 13.5-inch gun, in so far as ballistic qualities and penetrative power are concerned. The German guns, moreover, offer greater resistance to erosion; and, thanks to their smaller caliber, they take up less space, which permits smaller displacement of ship. The gun of small caliber also has the advantage of greater rapidity of fire and enables its ship to carry a larger supply of ammunition.

In order not to lose the lead and in order to meet the increase in thickness of armor in recent vessels, it has been thought expedient in England to increase again the power of the gun by adopting 15-inch pieces. A new method of manufacture of armor plate now being experimented with in England, but not yet put into effect, has perhaps influenced this step. It was no longer possible to increase the power of the 12-inch gun in the manner formerly

employed—that is to say, by increasing the length of the gun from 45 to 50 calibers and the initial velocity. Guns of that kind have been put in service, but they have not proved to be a step in advance; for, on account of the English system of wire-wrapping, they do not possess the necessary longitudinal stiffness and cannot bear the increase of gas pressure which is indispensable for an increase of muzzle velocity. In increasing the charge of powder, the erosion became so great that it rapidly reduced the accuracy of fire and rendered the gun unservicable after a very limited use. Guns of 13.5-inch caliber and 50-caliber length have never been manufactured in England. It was necessary, therefore, to find an expedient. Although an increase of initial velocity is, according to the formula for kinetic energy, the most efficacious measure, the caliber was increased to 15 inches and the initial velocity was reduced below the value used up to that time for guns of large caliber. That gave larger projectiles, from which resulted a larger bursting charge and a superior penetrating power at long ranges, in consequence of a less rapid loss of velocity along the trajectory and hence an increased effect at the target and less wear on the matériel. There are also obtained better results in fire at long range, since a heavier projectile more easily withstands atmospheric influences, which vary every day. Concurrent with this development, there is said to be a tendency to abandon wire-wrapped guns in favor of hooped guns, the manufacture of which, however, does not yet seem to have been crowned with success in England.

Increase of the weight of the projectile naturally brings with it increase of difficulty in loading (by reason of the larger caliber) and diminution of ammunition supply.

In order not to increase unduly the displacement of the ships, the number of guns of the primary armament on ships of the *Queen Elizabeth* class has been reduced to eight, while, at the same time, there is a return to heavy intermediate armament, which Germany has always retained. The intermediate armament, according to recent information, will comprise sixteen 6-inch guns, mounted in a center line, armored casemate on the upper deck.

The weight of an English 12-inch, 50-caliber gun is about 69 tons, and the weight of a 13.5-inch, 45-caliber gun about 80 tons. It will be understood, then, that there are voices in England which are being raised against the introduction of the 15-inch gun and which are demanding, as for instance Admiral Sir Cyprian Bridge's, that the 13.5-inch gun be retained as meeting all present needs.

In order to give an idea of the figures involved, we shall recall that the projectile of an English 12-inch gun weighs 850 lbs.; that of a 13.5-inch gun, 1250 lbs.; and that of a 15-inch gun weighs more than 1760 pounds.

The weight of steel in one broadside of the ten 12-inch guns of the *Dreadnought*, is, therefore, about 8500 lbs.; of the ten 13.5-inch guns of the *Orion*, about 12,500; and of the eight 15-inch guns of the *Queen Elizabeth*, about 14,000.

The gun armament of a German ship of the *Helgoland* class costs nineteen million marks (twelve 12-inch, 50-caliber guns; fourteen 6-inch, 45-caliber guns; and fourteen 3.5-inch, 40-caliber guns); the torpedo equipment costs one million and four hundred thousand marks (six submerged tubes of a caliber of, probably, 20 inches); and the vessel (22,800 tons), including the machinery, etc., costs twenty million and seven hundred thousand marks.

As for other navies, it may be mentioned that France intends arming its 23,500-ton ships of the *Bretagne* class with ten 13.4-inch guns; that the

United States intend for their 28,000-ton ships of the *New York* and *Nevada* classes ten 14-inch guns; and that this last caliber is also projected for Italian and Japanese ships of the line of 28,000 tons. It appears from the tables published in Weyer's *Taschenbuch* that 14-inch, 15-inch, and 16-inch guns are being experimented with at the Krupp works: if the necessity for an increase of caliber makes itself imperatively felt in Germany, the German works will certainly be prepared.

The weights of the new Krupp 14-inch, 15-inch, and 16-inch, 50-caliber guns are respectively 69.7, 85.8, and 104.1 tons, while the 12-inch, 50-caliber gun weighs only 44 tons. These figures enable one to appreciate the increase in weight that is involved and the increase in displacement resulting therefrom.

The jump from the total weight of 724 tons of the *Hercules* class (ten 12-inch, 50-caliber guns and sixteen 4-inch, 50-caliber guns) to ten 13.5-inch, 45-caliber guns and sixteen 4-inch, 50-caliber guns of the *Orion* class has brought, besides a rather unimportant increase of armored surface, an increase of 2700 tons displacement. The jump from the ten 13.5-inch guns of the *Iron Duke* class to the eight 15-inch guns, and from the twelve 2.25-inch guns to the as yet undetermined, but probably not smaller, number of 4-inch guns of the *Elizabeth* class will call for another increase in displacement of about 2000 tons.

In addition to increased penetration, the object of an increase of caliber must be, especially, increased explosive effect for the new projectiles which, however, are much improved in other respects. The explosive effect is extraordinary, whether explosion occur after partial penetration or after complete perforation.

Austria-Hungary also has up to the present adhered to the 12-inch gun.

—*Journal des Sciences Militaires.*

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## NEW EXPERIMENTS ON AIR RESISTANCE

By Capt. J. H. Hardcastle, *late* R. A.

### I

In this article it is proposed to make some attempt to collect the scattered information already in existence relating to the best shape for projectiles and to present it in the most useful form by translating, when necessary, metric units into ordinary imperial measures. A quantity of useful results was published last year in Germany in *Artilleristische Monatshefte* over the names of Cranz, von Eberhard and Vallier, amongst others, and notably, complete figures were given for the German *S* bullet obtained by two different instrumental electric methods. In England the elevation table for the Mark VII bullet up to 2000 yards is now available for analysis. These, combined with the experiences of match rifle bullets, and the latest Krupp results for various shapes of artillery projectiles, afford a fairly sufficient foundation for theorists to commence an attempt to construct a general expression to represent the influence of the coefficient of form.

As the whole science of exterior ballistics rests upon an experimental basis, Table I has been prepared showing the resistance $p$ lbs. per circular inch to eleven different projectiles which have been examined at one time or

TABLE I. Value of $p$, the resistance of the air in lbs. to a 1-inch projectile.

| Velocity, f. s. | Bashforth | New Tables | Spherical | S Bullet | S flat half-scale | $K_1$ | $K_2$ | $K_3$ | $K_4$ | $K_5$ | K flat half-scale |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3,940 | 68.2 | 48.2 | — | — | — | 52.0 | 44.2 | 41.0 | 38.9 | 35.4 | 82.6 |
| 3,280 | 47.2 | 35.5 | — | 19.0 | — | 36.4 | 31.1 | 28.8 | 28.1 | 26.1 | 55.7 |
| 2,623 | 30.0 | 24.4 | — | 14.0 | 27.9 | 24.4 | 20.9 | 19.2 | 19.4 | 18.2 | 34.4 |
| 1,968 | 16.9 | 15.8 | 25.3 | 9.7 | 15.1 | 15.2 | 13.1 | 12.2 | 12.6 | 12.2 | 18.1 |
| 1,640 | 11.9 | 11.4 | 17.3 | 7.5 | 10.0 | 11.0 | 9.6 | 8.9 | 9.3 | 9.4 | 12.0 |
| 1,476 | 9.65 | 9.45 | 13.8 | 6.42 | 7.75 | 9.0 | 7.8 | 7.4 | 7.65 | 7.72 | 9.45 |
| 1,313 | 7.68 | 6.80 | 10.5 | 5.16 | 5.76 | 6.8 | 6.05 | 5.71 | 5.95 | 6.13 | 7.14 |
| 1,247 | 6.50 | 5.65 | 9.15 | 4.5 | 4.8 | 5.65 | 5.02 | 4.75 | 5.03 | 5.17 | 6.05 |
| 1,181 | 5.63 | 4.73 | 7.95 | 3.8 | 4.0 | 4.70 | 4.20 | 3.93 | 4.27 | 4.42 | 5.30 |
| 1,115 | 4.84 | 3.38 | 6.76 | 2.9 | 3.1 | 3.28 | 2.88 | 2.78 | 3.14 | 3.53 | 4.58 |
| 1,049 | 3.15 | 2.23 | 5.47 | 1.8 | 2.5 | 1.91 | 1.80 | 1.75 | 1.91 | 2.08 | 3.66 |
| 984 | 2.15 | 1.75 | 4.12 | 1.24 | 1.94 | 1.41 | 1.31 | 1.27 | 1.36 | 1.49 | 2.87 |
| 918 | 1.78 | 1.45 | 3.41 | 0.95 | 1.6 | 1.14 | 1.04 | 1.00 | 1.08 | 1.17 | 2.42 |
| 853 | 1.43 | 1.16 | 2.73 | 0.85 | 1.4 | 0.92 | 0.86 | 0.82 | 0.86 | 0.94 | 1.94 |
| 787 | 1.13 | 0.980 | 2.23 | 0.75 | 1.1 | 0.74 | 0.70 | 0.68 | 0.68 | 0.74 | 1.52 |
| 722 | 0.972 | 0.86 | 1.92 | — | — | 0.62 | 0.60 | 0.58 | 0.58 | 0.61 | 1.21 |
| 656 | 0.825 | 0.75 | 1.61 | — | — | 0.53 | 0.51 | 0.50 | 0.49 | 0.51 | 1.00 |
| 328 | 0.20 | 0.24 | 0.385 | — | — | 0.17 | 0.16 | 0.16 | 0.17 | 0.16 | — |
| Index | 2.0 | 1.67 | 2.0 | 1.38 | 2.2 | 1.79 | 1.77 | 1.75 | 1.67 | 1.56 | 2.2 |
| $p$ for 1,500 f.s. | 9.7 | 9.5 | 13.9 | 6.4 | 7.8 | 9.0 | 7.8 | 7.4 | 7.6 | 7.7 | 9.5 |
| $a$ f.s. | 850 | 920 | 780 | 850 | 850 | 850 | 850 | 850 | 850 | 850 | 790 |
| limit f.s. | 980 | 1,050 | 980 | 920 | 920 | 920 | 920 | 920 | 920 | 920 | 920 |
| $n$* | 1.10 | 1.0 | 1.62 | 0.60 | 1.86 | 1.0 | 0.87 | 0.81 | 0.81 | 0.76 | 2.20 |

* $n$ is the same as $c$ in our formulas.—*Editor.*

Note.—The index at foot of table shows the approximate law above 1500 f.s., beginning with the value of $p$ given on the next line. Also if $p$ is made equal to 0 at the velocity $a$ f.s., a straight line joining $p$ for 1500 f.s. and $p$ for $a$ f.s. represents fairly the value of $p$ from 1500 f.s. to the velocity shown against limit f.s. The approximate value of the coefficient of form is shown on the last line against $n$.

another by electrical appliances over a very wide range of velocities, from 4000 feet per second downwards. Three of them are familiar to English students, being: (1) the original Bashforth figures extended by extrapolation to 4000 f.s.; (2) the new two caliber ogival head taken from the new tables; (3) the old Bashforth results for spherical projectiles, invaluable for shot gun work.

The new figures for flat-headed proof projectiles are still kept confidential. Eight new sets of results are added. The 8mm. *S* bullet of 154 grains, and also a flat-headed bullet of the same caliber, are from Becker and Cranz's article in *Art. Monat.*, September 1912. Six Krupp projectiles from von Eberhard's article of the same date complete the series and these are distinguished by the prefix *K*. $K_1$ is the Krupp "normal shot" of two-caliber ogive finished with a circular point or aperture of 0.36 caliber radius shown in Fig. 1. $K_2$ is three caliber radius and 0.36 aperture. $K_3$ is 5.5 caliber radius and 0.36 aperture. $K_4$ is three-caliber radius and 0.25 aperture. $K_5$ is three caliber radius with no aperture but a sharp point, and *K* flat is a flat-headed proof cylinder, presumably with a slight radius at the corner. As all the German results were shown diagrammatically, results had to be pricked off at velocities measured in meters per second, so that the velocities given in feet-per-second aıe not round numbers. The Krupp results below 250 m.s. or 800 f.s. are admittedly questionable, and from internal evidence all results, both English and foreign, below the velocity of sound, 1100 f.s. are more or less doubtful, because the probable instrumental errors are then comparable with the results which are being sought for.

The most obvious thing to do with these values of the resistance is to plot them on a large sheet of squared paper in order to see whether they show any sort of symmetry from which the coefficient of form can be determined by inspection, for use with the existing ballistic tables. There are several methods of plotting resistances, and each has its own advantages and objections. First of all $p$ can be plotted against the velocity, and this has been done on Fig. 2 by a dotted line for the values in the new tables. The objection to this method is that below 1000 f.s. the scale is so small as to be illegible. But the advantage is that it can be seen that some such straight line as that drawn in solid from 850 f.s. very nearly represents the facts. Similarly the value for the *S* bullet has been drawn in solid and a dotted straight line near it for comparison. As both these straight lines pass through the point $p = 0$, $v = 850$ f.s., the angles they make with the perpendicular give at once a true measure of the coefficient of form at velocities above 850. The bottom line of Table I shows the result of applying this method, taking 850 as the radiant point. It may be a rough and ready way of getting at the value of $n$, but it is quite accurate enough and avoids a host of philosophical difficulties as to the best average value of unsysmmetrical quantities.

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II

In last month's article there were given in tabular form the values of $p$, the resistance of the air in lbs. per circular inch, for eleven different projectiles of various shapes and over a range of velocities from 4000 f.s. downwards to 300 f.s. The bottom line of this table gave the average value of $n$ for each projectile at any velocity greater than 850 f.s. This value was obtained by plotting, as on Fig. 2, the values of the resistance against the velocity, and

running a straight line as fairly as possible along the rather irregular curve so drawn for each projectile, and taking that straight line instead of the curve as a basis for averaging. This is possible because at about 4000 f.s. the resistances run into figures in the region of 50 lbs. At 850 f.s. they are down to about 1 lb., and at lower velocities they are smaller still. By supposing the resistance to vanish at 850 f.s., the point on the diagram represented by $p = 0$, $v = 850$, becomes the radiant point of all the resistances, and the straight lines give reasonable resistances above the velocity of sound, where the resistance becomes of importance and also can be ascertained with considerable precision. In the course of the remarks to follow, frequent references will be made to the diagram Fig. 2, published in the previous number, and the reader will do well to have the same before him.

On Fig. 2, another dotted and solid curve is also shown, the dotted one being the $K$ tabulated in our new tables, and the solid one the $K$ corresponding to the solid straight line of $p$. $K$ itself is a number given directly by the multi-screen chronograph, and is defined by the expression

$$p = \frac{K}{g}\left(\frac{V}{1000}\right)^3 \text{ where } g \text{ is gravity.}$$

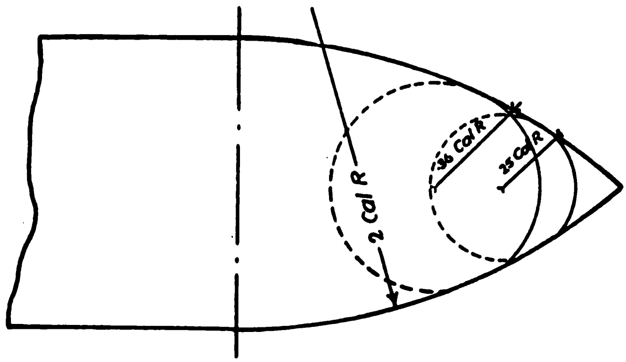



FIG. 1. 1346

It is sometimes, and erroneously, said on the Continent that by tabulating $K$, Bashforth assumed a cubic law. He in fact did nothing of the kind, as he started by breaking away from all ideas of finding a law, and he tabulated $K$ because it is a simple multiple of the second difference column given by a multi-screen chronograph with equally spaced screens.

Every time, therefore, that he seemed to smooth or adjust $K$ in an experiment, he really located an instrumental error, and measured that error, and so kept in actual touch with the want of perfection necessarily inherent in his machine. Another more important reason for tabulating $K$ is to smooth the experimental values of $K$ until they can be precisely equated to an expression or series of expressions of the form $K = a\,V^n$, which is a necessary preliminary to calculating tables by Ingalls' method.

This smoothing in order to obtain an index, was clearly shown in the figure by the three pieces of straight line forming the double bend in the dotted $K$ curve. The solid $K$ curve is also smooth but corresponds to the "fudged" straight line for $p$, and is useless for Ingalls' method, because its equation is not of the required form.

It is well to have these curves clearly before the mind when searching for a general expression for the coefficient of form, because all the published figures have been manipulated once already to bring them to the required smoothness, so that they must not be blindly followed. Our own new tables show signs of having been rectified by a constant multiplier to increase the value of the resistances and make it nearly identical with those in Ingalls' own elaborate tables, which the new tables supersede. Ingalls' were calculated from Krupp's results with his "normal-shot" with the large aperture, and

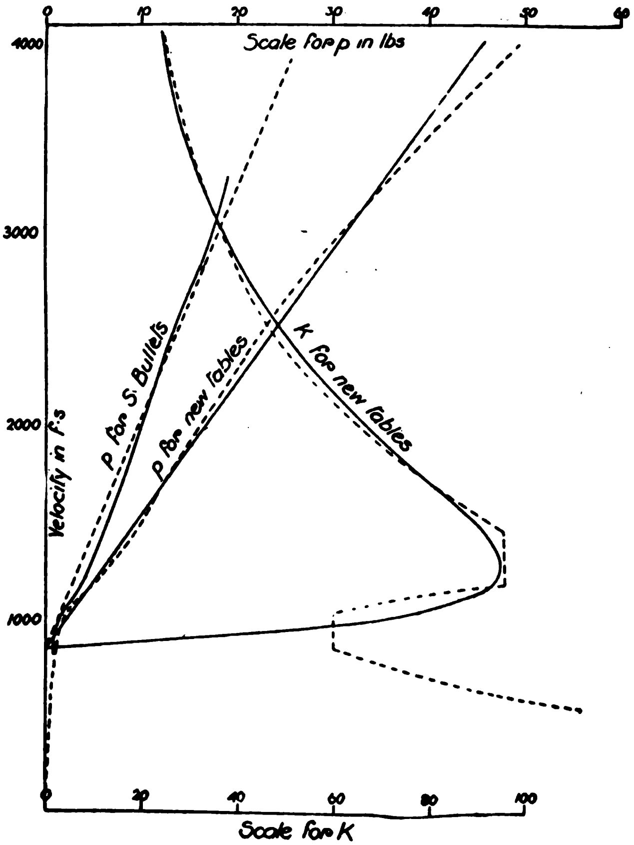



FIG. 2. 1347

these are shown as $K_1$ in Table I, with an average value of $n$ of unity despite the aperture, which should increase the resistance by five per cent and make $n$ equal 1.05. In Fig. 3, yet another way of plotting results is shown by means of $k$, or the Newtonian law, resistance varying as the square of the velocity. The factor $k$ is defined by $p = \frac{k}{g}\left(\frac{v}{1000}\right)^2$, so that $k$ is constant for the Newtonian law used so largely in aviation design. Here the dotted line corresponds to the published resistance in the new tables and the smooth firm line to the "fudged" straight line for $p$ on Fig. 2, but the firm line for the $S$

bullet is Cranz's own figures untouched, and it is unnecessary to refer to his article to be sure that this is the curve on which he did his smoothing. From it I calculated the firm $S$ bullet line on Fig. 2, which shows severe bends at about 1000 f.s.

All the German results in Table I. were published as smooth curves of this $k$, and it is clear that in the region of the velocity of sound the value of $k$ is shifting so rapidly that it must be bound up with the actual velocity of sound at the very moment the shot is fired. The same remark applies to the value of $K$ in Fig. 2, which as already explained is a number given directly by the second difference of the time column.

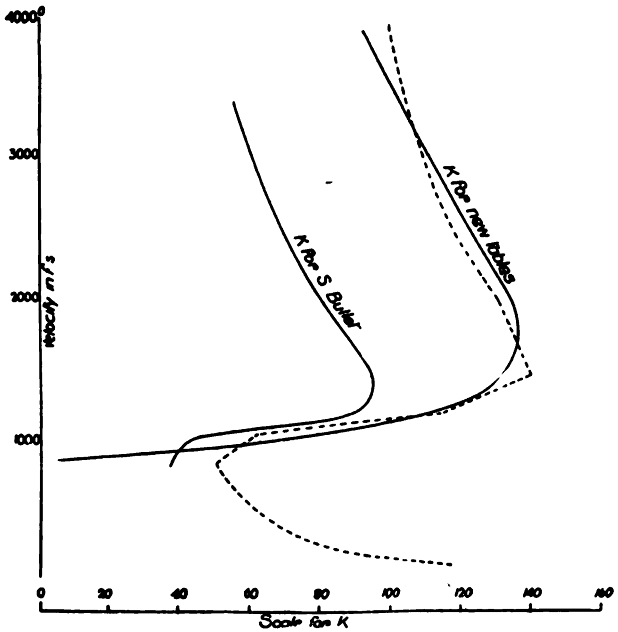



FIG. 3. 1348

It is clear then that between velocities of 900 f.s. and 1300 f.s. or 200 f.s. on each side of the velocity of sound all experimental results should be treated with suspicion and the "fudged" straight line for $p$ is as likely to be correct as any other value during the passage of this region. The straight lines which lie evenly among the published figures are indicated at the foot of Table I and 850 f.s. is a good average radiant point. Below about 920 f.s. the resistance to small arm bullets is very doubtful indeed, but fortunately also of insignificant interest.

Vallier put forward an expression for $n$ at velocities above 1100 f.s. about twenty years ago containing the velocity in meters per second as a variable and the apex angle in degrees $A$ of the ogival head. It is written

$$n = A \frac{v-(180+A)}{20.7\ (V-263)}$$

and it varies very slowly with velocities over 1500 f.s. Another suggestion

is given by von Eberhard of a form suitable for transforming the tables. He proposes to write:

$$n = p + \frac{q}{v} + r\,v,$$

where $p$, $q$ and $r$ are to be variables depending upon the shape of the head. He omits to show how the shape can be defined. For instance, the Metford head and the Mark VII head are of no precise geometric shape. The formula in the *Text Book of Small Arms* is but an inelegant way of writing

$$n = 1.51 \sin \tfrac{1}{2} A,$$

which in turn is hardly distinguishable from

$$n = \sqrt{\frac{2}{m}} \text{ or } 1\tfrac{1}{2}\frac{l}{m}$$

where $m$* is the number of calibers radius of the ogive and $l$ is the length of the head in calibers.†

In *Rivista di Artiglieria e Genio* for March of this year, there is a useful article by Colonel Ricci of the Italian artillery, entitled "An *a priori* Research into the Coefficient of Form."‡ It contains a summary of the results obtainable by most theoretical investigations of any note into the value of $n$, beginning with Newton's law, familiarly known as the sine-squared law, and ending with Eiffel and Riabouchinsky's aerodynamical experiments for aviation. Newton's law applies to the case of a medium consisting of a cloud of particle dust. The number or weight of the particles encountered in unit time varies directly as the velocity, and the momentum lost varies also as the velocity, and each also varies as the sine of the angle of incidence, so that the total effect varies as the square of the velocity and of the sine. All the other theories include the square of the velocity, but von Lössl's (or Hélie's as a particular instance), have the sine simply and not squared. Ricci gives a diagram of the results, plotting $n$ against the semi-angle of the vertex of the projectile or the length or the radius of the head in calibers. It then appears that the inelegant formula already quoted from our text book is really Hélie's without acknowledgment, and that von Lössl's or Hélie's give results in accordance with experience. It seems to follow from this that von Lössl's general theorem is probably correct, but such an inference is illogical and therefore improper. His theorem is bound up with the resistance varying as the square of the velocity, and as experiment shows that not to be true, the accuracy of his formula is merely fortuitous. It is no more a true law than my rule of thumb $n = \sqrt{\frac{2}{m}}$, and not so easily remembered or applied.

* $m$ is the same as $n$ in our formulas.—*Editor.*

† Footnote for JOURNAL U. S. ARTILLERY.—The formula $l = \tfrac{1}{2}\sqrt{4m - 1}$ [see *Artillery Circular N*, p. 196] can be written with sufficient accuracy $l = 0.99\sqrt{m}$.

Both Helie's law and von Lossl's can be also written $k = \sqrt{\frac{2.1}{m}}$. Whence arises this very simple relation, $k = \frac{1.43}{l}$, when a head of two calibers ogive is taken as unity; or, in words, the resistance varies inversely as the length of the head measured in calibers. As this is also true for similar figures other than ogives, as experiment shows, up to $m = 20$ and its equivalents, the sine of the semi-angle of the apex has no place in a general formula. Alston Hamilton's theorem introducing the superficies of the head as transformed by Ricci seems then to be the best guide. My old formula with the square root of the length of head was based on insufficient data, I now know. In the absence of any knowledge of the stream lines in air at these velocities, mathematicians must be helpless as such.—J. H. H. 6–8–13.

‡ It is hoped that a translation of that article will be presented in the next number of the JOURNAL OF THE UNITED STATES ARTILLERY.—Editor.

The only way I can find of sorting out the effect of the various head is by noticing that at and above 1500 f.s. the resistance can always be written as:

$$p = a\,v^b \text{ or } \log p = \log a + b \log v,$$

where $b$ is as shown on Table I against index, and diminishes steadily as the heads get sharper, and where $a$ has no particular significance. On the whole, although it is plain that $n$ does vary with the velocity as well as with the shape, it is very unlikely that the results of analysis will ever be more trustworthy than common sense and experiment in determining the value of the coefficient of reduction for a new shape of projectile, or that any general expression will ever be found for the coefficient of form.

—*Arms and Explosives.*

✤ ✤ ✤

## ON A MODIFIED FORM OF STABILITY TEST FOR SMOKELESS POWDER AND SIMILAR MATERIALS

By H. C. P. Weber

Some time ago an investigation on the stability of nitrocellulose plastics was undertaken at the Bureau of Standards, and the question of the stability of these materials at normal and elevated temperatures was one of the questions studied.

One of the stability tests employed in that investigation seems of sufficient interest to warrant calling attention to it, especially since it does not seem possible to carry the investigation further at present.

The papers to which reference has been made in connection with this subject are tabulated at the end of this paper and will not be cited again in detail.

There is, perhaps, no need for going into details regarding all the various tests proposed. While there are many of them, each having its own particular advantage, only a few are at all generally applied. The reason for adding to their number is that while this test is an explosion test, and therefore simple and rapid, it is in reality a determination of the change of decomposition velocity with rise in temperature and, as such, a measure of stability.

Various investigators have touched upon the influence of the rate of heating on the result, whether it be in the explosion tests or in methods depending on the amount or rate of gas evolution. For this reason the rate of heating in the explosion test is defined within certain limits. The decomposition of nitrocellulose is autocatalytic, and when a certain surrounding temperature is attained, say 135° C, nearly all samples of nitrocellulose will explode if kept in surroundings of that temperature long enough. The temperature of the decomposing material may be a few or many degrees above 135°. In the investigation of nitrocellulose plastics we have repeatedly seen differences of 30° and 40° between the temperature of the surroundings and of the sample when the substance went off. The amount of this difference depends on the mass of the material and its heat conductivity and on the heat conductivity of the system used for test. These factors enter into the German 135° test as well as into the ordinary high temperature explosion test. In the former the time will vary with the heat insulation; in the latter the explosion temperature will vary with the rate of heating.

The apparatus used for the test is shown in Fig. 1. The heating bath

consists of a crucible of iron or nickel, about 10 cm. in diameter and of approximately the same depth. The cover is of sheet metal, about 3 mm. thick, with a flange that fits snugly into the crucible and projects slightly beyond the rim. One hole through the center of the cover is just large enough to permit the thermometer to pass. Symmetrically distributed around the center of the plate are eight openings 15 mm. in diameter. The heavy metal supporting tubes are about 4 cm. in length and about 12 mm. internal diameter. The lower end of the tube is flanged, so that the tube rests securely on the

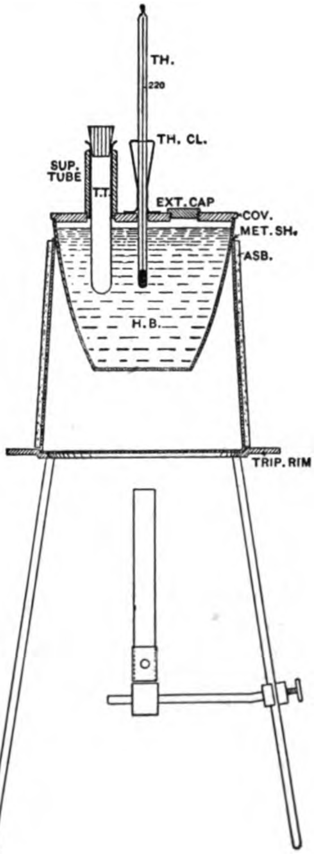



FIG. 1. 1349

cover. The test tubes are about 9 cm. long and must be of such diameter that they will just slip freely into the supporting tubes. A number of extra caps are provided to cover openings not intended to be used during the test. The heating liquid may be either paraffin, glycerin, or similar inert liquid, which may be heated to 200° without boiling or fuming strongly.*

The test tubes should dip about 4 or 5 cm. into the heated liquid, so that their ends will be at about the center of the heated mass and may readily be

* This form of apparatus has been devised by C. E. Waters in connection with work on lubricating oils.

removed one at a time and replaced by fresh ones. For each explosion a clean tube should be taken.

The thermometer is supported by a metal clip which rests on the cover, the bulb being on a level with the lower ends of the test tubes. The thermometer used was standardized. Since the mercury thread projected but little above the highly heated zone, the stem correction was found to be negligible. This should be checked with each apparatus and thermometer for the various temperatures when the apparatus is put together.

The heating bath is suspended in a conical piece of sheet metal wrapped with asbestos. The metal shield (Met. Sh.) is cut so that the crucible will hang securely in the upper smaller opening, while its larger end rests in the flanged tripod rim. With this apparatus and a small gas flame it has been easily possible to maintain the temperature constant for 15 or 20 minutes within half a degree. It is most convenient to have the burner set so that there is a tendency for the temperature to fall and to use a small accessory flame momentarily whenever necessary. With a temperature regulator or with electrical heating the ease of manipulation might, no doubt, be increased.

One or two stop watches* complete the equipment. When the apparatus has attained equilibrium at the desired temperature, one or more of the test tubes is loaded by dropping in the sample of powder, the stop watch is started, and a cork is dropped into the mouth of the test tube. The time until the explosion takes place is then noted.

The grains of the 6-pounder smokeless powder are of convenient size to use directly. Powders of larger caliber should be cut into pieces weighing about 0.2 g. each. Each sample of powder was tested at four temperatures, 160°, 170°, 180°, and 200°. For the present purpose at least three tests were made at each temperature interval and a curve was drawn through the average values.

The following series on powder A shows how closely duplicates may be expected to agree:

| | | | | | Av. | Max. Var. |
|---|---|---|---|---|---|---|
| 200° C. | 1′ 44″; | 1′ 48″; | 1′ 44″; | 1′ 48″; | 1′ 45″ 1′46″ | ± 2% |
| 180° | 2′ 55″; | 3′ 06″; | 3′ 10″; | | 3′ 04″ | − 5% |
| 170° | 4′ 17″; | 4′ 30″; | 4′ 28″ | | 4′ 25″ | − 3% |
| 160° | 14′ 20″; | 17′ 40″; | 17′ 31″ | | 16′ 36″ | −14% |

In general the discrepancies appear to be greater at the lower temperatures. This is to be expected, since the curves given further on show to what extent the influence of small temperature variations is magnified in the region of 160°. Furthermore, the irregularities are more pronounced in the "poor" powders.

The following set shows what can be expected as to reproducibility of the complete curve. The sample used was L and the second test was made one month later than the first. The averages only are given:

| | 200° C | 180° C | 170° C | 160° C |
|---|---|---|---|---|
| I | 1′ 31″ | 2′ 18″ | 3′ 39″ | 7′ 11″ |
| II | 1′ 27″ | 2′ 31″ | 3′ 43″ | 7′ 30″ |

* I have found the type of stop watch with two second hands, which may be stopped independendently, the most convenient form. With two of these at least four samples may be observed simultaneously.

The following table and Fig. 2 give the results obtained with 10 samples of smokeless powder and two samples of nitrocellulose. The samples were obtained through the Navy Department, and I am indebted to the courtesy of G. W. Patterson, powder expert at Indian Head, for the selection of three classes, good, fair, and poor, and for the description of these samples, which I quote for comparison with the explosion periods:

Nitrocellulose A.—"Specially prepared. Heat test, potassium-iodide starch, at 65°.5 C, 4 minutes; German test at 135° C, 9 minutes for litmus red."

Nitrocellulose B.—"Heat test, potassium-iodide starch, at 65°.5 C, 42 minutes. German test at 135° C, 38 minutes for litmus red."

Powder Sample A.—"Six-pounder. Diphenylamine as stabilizer. German test at 135°C, litmus red, 2 hours 35 minutes, explosion 5 hours plus. Surveillance test at 80° C, 87 days; at 65°.5 C, 307 days."

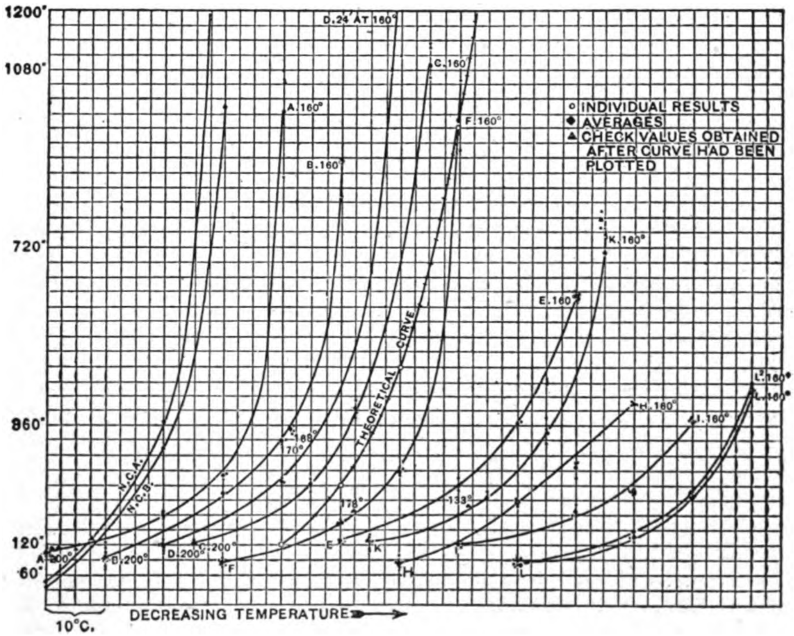



FIG. 2. 1350

Sample B.—"Medium caliber. Diphenylamine as stabilizer. German test at 135° C, litmus red, 2 hours 17 minutes, explosion 5 hours plus. Surveillance test at 65°.5 C, 271 days."

Sample C.—"Large caliber. Diphenylamine as stabilizer. German test at 135° C, litmus red, 1 hour 25 minutes, explosion 5 hours plus. Surveillance test at 65°.5 C, 245 days plus."

Sample D.—"Large caliber. No stabilizer. Rosaniline as indicator. German test at 135° C, litmus red, 2 hours, explosion 5 hours plus. Surveillance test at 65°.5 C, 60 days."

Sample E.—"Medium caliber. No stabilizer. Rosaniline as indicator. German test at 135° C, litmus red, 1 hour 35 minutes, explosion 5 hours plus. Surveillance test at 65°.5 C, 74 days."

Sample F.—"Six-pounder. Contains rosaniline and diphenylamine. German test at 135° C, litmus red, 2 hours 25 minutes, explosion 5 hours plus. Surveillance test at 65°.5 C, 375 days; at 80° C, 64 days."

Sample H.—"Manufactured in 1901. When last tested it gave German test at 135° C, explosion in 41 minutes. Surveillance test at 65°.5 C (1907), 79 days."

Sample I.—"Manufactured about 1901. When last tested, it gave German test at 135° C, explosion in 33 minutes; surveillance test at 65°.5 C, 82 days."

Samples K and L.—"These are both in very poor condition, giving only one day surveillance test."

The explosion periods obtained on these samples are as follows. The value underscored is the average value. [See page 243.]

The curves embodying these results are given in Fig. 2. The curve marked "theoretical curve" is obtained on the assumption that the reaction velocity doubles for every 10° C. While the curves obtained from the explosion periods are of the same general type, it is apparent that the relation is not so simple as that shown by the "theoretical curve." What influence the stabilizer has upon the direction of the curves it is difficult to say with the data at hand. It does not follow that the stabilizer will affect the explosion test in the same manner as it does the heat test or the surveillance test. The stabilizer, while it removes the products of decomposition, may of itself act as a positive or negative catalyzer. If the decomposition be considered as the dissociation of an ester, the presence of a substance removing the products of decomposition will increase the rate. This has been noticed by Mittasch* for nitrocellulose with various basic additions and has been confirmed by myself in the case of pyroxyline plastics containing zinc oxide.

That the curves do actually represent the stability of the powder with changing temperature and are not accidental is shown by the reproducibility of the various points along the curve, as shown in the table; by the fact that the curve having been determined by four points, determinations made at varying temperatures are found to fall on the curve; and by the fact that the complete curve can be reproduced at widely varying intervals. (See curves L′ and L″.) The curves are undoubtedly characteristic for the sample. The deviations for individual points are not large enough to affect the general trend of the curve. What temperatures are chosen must probably be left to individual requirements; 190° would perhaps be preferable to 200°. At 150° we should have the apparent advantage that the differences between various samples become greater and the disadvantage that the test becomes slower and the results are more subject to accidental influences. The bend of the curve between 180° C and 160° C is, perhaps, its most characteristic portion.

The curves fall into three distinct groups for the samples tested, corresponding to their general classification of good, fair, and bad. The stable powders have a pronounced bend, while the ratio of explosion periods at 200° C and 160° C is at least 2 : 9. In the unstable samples this ratio falls as low as 2 : 3, and the points do not fit a smooth curve so well. The curves for the two samples of raw nitrocellulose are somewhat peculiar, being much flatter and corresponding more nearly to the theoretical curve.

The powders do not always fall in exactly the same order by this explo-

* Loc. cit.

### Explosion Periods

| Temperature | 200° C | 180° C | 170° C | | 160° C |
|---|---|---|---|---|---|
| Nitrocellulose: | min. sec. | min. sec. | min. sec. | min. sec. | min. sec. |
| | 33 | 5 20 | 30+ | | 30+ |
| A | 58 | 6 11 | | | |
| | 37 | 6 56 | | | |
| | 43 | 6 19 | | | |
| | 33 | 4 06 | | | |
| | 42 | 5 55 | 16 00 | | 30+ |
| B | 34 | 6 06 | 17 30 | | |
| | 36 | 5 22 | 16 45 | | |
| Powder: | 1 44 | 2 58 | | | |
| | 1 48 | 3 06 | 4 30 | | |
| A | 1 44 | 3 10 | 4 17 | | 14 20 |
| | 1 48 | 3 04 | 4 28 | | 17 40 |
| | 1 45 | | 4 25 | | 17 34 |
| | 1 46 | | | | 16 36 |
| | 1 54 | 3 37 | | | |
| | 1 15 | 3 54 | | | |
| | 1 65 | 3 44 | 5 23 | 5 44 | 14 20 |
| | 1 32 | 3 27 | 5 26 | 6 02 | 13 45 |
| B | 1 33 | 3 57 | 5 36 | 5 53 | 17 07 |
| | 1 41 | 3 44 | 5 28 | 5 57 | 14 57 |
| | 1 37 | | | | |
| | 1 27 | | | 168° | |
| | 1 25 | | | | |
| | 1 36 | | | | |
| | 2 04 | 4 05 | | | |
| C | 2 04 | 3 15 | | | |
| | 2 10 | 4 50 | 6 17 | | 17 45 |
| | 2 06 | 4 05 | 6 28 | | 18 25 |
| | 1 45 | 4 20 | 6 55 | | 18 18 |
| | 1 47 | 4 03 | 6 34 | | 18·09 |
| | 2 00 | 4 08 | 6 15 | 7 00 | 19 00 |
| D | 1 58 | 4 10 | 5 53 | 6 50 | 26 49 |
| | 2 10 | | 5 57 | 6 56 | 28 30 |
| | 2 30 | | 6 00 | 6 56 | 24 46 |
| | 2 00 | | | | |
| | 1 35 | 3 55 | 172° | 171° | |
| | 2 10 | 4 06 | | | |
| E | 2 10 | 4 18 | 6 10 | | 10 15 |
| | 2 05 | 4 06 | 5 58 | | 10 24 |
| | 2 10 | | 6 08 | | 10 29 |
| | 2 10 | | 6 05 | | 10 23 |

### Explosion Periods—Continued

| Temperature... | 200° C | 180° C | 170° C | | 160° C |
|---|---|---|---|---|---|
| Powder—Cont. | *min. sec.* | *min. sec.* | *min. sec.* | *min. sec.* | *min. sec.* |
| | 1 40 | 2 47 | 3 33 | | 15 16 |
| | 1 41 | 2 45 | 3 23 | | 15 47 |
| | 1 48 | 2 49 | 3 31 | | 17 40 |
| F.......... | 1 45 | 2 47 | 3 29 | | 16 14 |
| | 1 45 | | | | |
| | 1 38 | | | | |
| | 1 43 | | | | |
| | 1 15 | 3 32 | 4 45 | | 6 47 |
| | 1 29 | 3 35 | 4 17 | | 6 48 |
| | 1 10 | 3 28 | 4 44 | | 6 50 |
| H.......... | 1 15 | 3 32 | 4 35 | | 6 48 |
| | 1 38 | | | | |
| | 1 22 | | | | |
| | 1 28 | | | | |
| | 2 04 | 3 05 | 3 50 | | 6 13 |
| | 2 10 | 3 05 | 3 49 | | 6 00 |
| | 2 02 | 3 20 | 3 56 | | 6 17 |
| I........... | 2 00 | 3 10 | 3 50 | | 6 10 |
| | 2 05 | | | | |
| | 2 05 | | | | |
| | 2 04 | | | | |
| | 2 05 | 3 29 | 5 55 | | 11 12 |
| | 2 05 | 3 30 | 5 22 | | 11 8 |
| | 2 14 | 3 50 | 6 15 | | 12 38 |
| K.......... | 2 17 | 3 36 | 5 51 | | 11 00 |
| | 1 50 | | | | 12 28 |
| | 1 52 | | | | 13 00 |
| | 2 04 | | | | 11 54 |
| | 1 31 | 2 13 | 3 38 | | 7 02 |
| | 1 22 | 2 18 | 3 33 | | 7 12 |
| | 1 27 | 2 22 | 3 47 | | 7 20 |
| L........... | 1 35 | 2 18 | 3 39 | | 7 11 |
| | 1 30 | | | | |
| | 1 40 | | | | |
| | 1 31 | | | | |

K, at 183°, 3-20, 3-29; at 160°, 12-43, 13-20 minutes and seconds.

F, at 178°, 3-00, 3-13 minutes and seconds.

A, at 199°, 1-47; at 198°, 1-53; at 197°, 1-52; at 195°, 1-56; at 193.°5, 2-12 minutes and seconds.

sion test as they do by the surveillance or the heat test, but I think this is true to the same extent for the 135° German explosion test and the ones mentioned. This appears by comparison of the customary tests on samples D and H:

D, German test 135° litmus red 2 hours, explosion 5 hours; surveillance 60.
H, German test; explosion 41 minutes; surveillance 79.

From the results given it is evident that one explosion temperature, even if time is considered, does not give much information, while the determination of the characteristic curve does yield definite and specific information.

On account of the complexity of the conditions the test can hardly be expected to tell all that is to be known, but I believe that with sufficient data it may even be made to throw some light on the actual effect of the stabilizer on the natural decomposition velocity of the powder, as distinguished from the length of time before the decompostion products become noticeable.

### CONCLUSION

The proposed method gives more accurate determinations of the explosion temperature than the method of heating with rising temperature.

It gives a better comparison of the relative stability of explosive substances.

The test is in effect a determination of the rate of change of decomposition velocity with change of temperature and is as such characteristic for each sample.

WASHINGTON, June 22, 1912.

—*Bulletin of the Bureau of Standards.*

## THE TRUE CENTERING OF PROJECTILES

### TO THE EDITOR OF *Engineering*

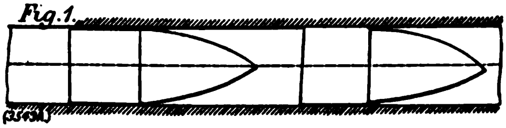
SIR,—That the true and exact centering of projectiles, by which is meant the coincidence of the axis of shot and bore, has not been before developed and adopted will be a surprise to laymen; it is a question which engineers would have tackled first, but, unfortunately, the design and construction of everything connected with ordnance seems to have drifted along in a haphazard way.

Lynall Thomas, F.R.S. (see his book, *Rifled Ordnance*, 1859, page 84) endeavored to solve this question, also others, from a scientist's standpoint.

He says: "Making experiments with long shot, I found a difficulty in procuring with them an expansion sufficiently even to cause their axis to coincide with the axis of the bore, etc. (see Fig. 1).

"After many attempts I succeeded (see Figs. 2 and 3) in effecting this object by means of the ferrule B, which acts in the following manner: Upon the explosion of the powder, the lower ring D is caused to expand and fill the grooves, by means of a wooden sabot, and at the same moment is driven, together with the iron ring B, in a forward direction; the latter, acting upon the top ring C, causes it to expand sufficiently to fill the bore (should be 'and grooves')."

Fig. 1.




1351

Fig. 2.

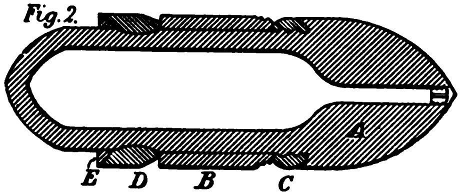
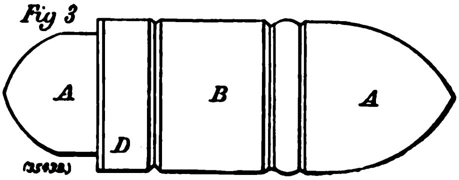
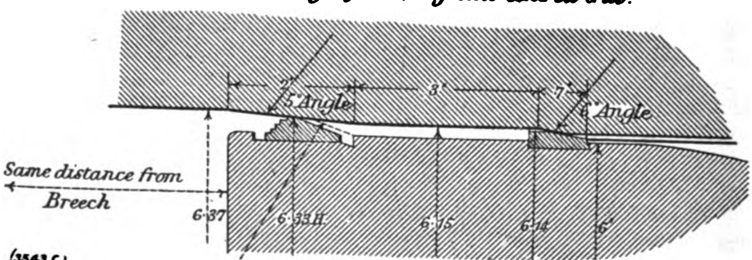



Fig 3




1352

Fig. 4 6 IN. GUN CHAMBER
Stanbridge System. Projectile centred true.




Position of rear band before loading

1353

The factors which militate against the success of any such schemes—and several to expand and center after firing have been submitted to the Admiralty of late—are:

1. Centering dead true cannot take place by trusting to expansion, as the rifling will not impress itself equally.

2. That centering must be effected before firing, the pressure and velocity preventing any readjustments. This is well known to cartridge-makers, sheet-metal rollers, and others. With the former, taper dies will never right and produce concentric walled cases from a blank placed untrue in the die.

Needless to say, Lynall Thomas admits in his book, page 194, that failures were frequent when his ideas were applied to larger calibers.

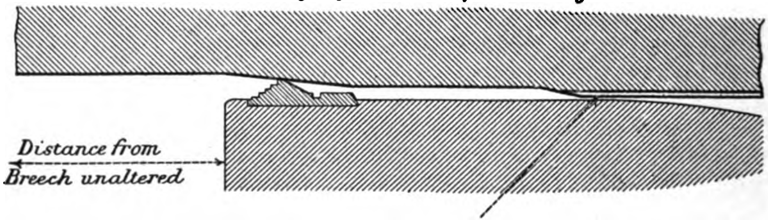
The only true way of centering is by the application of the formula in use on the lathe, etc.—viz., two cones, two counter cones, and a sliding adjustment parallel to the axis of the said cones. This is the system invented by me, illustrated in Fig. 4, which shows it applied to a 6-inch gun. Practically speaking, the present band has been divided (no changes are made in the diameters), a part forming a front centering-band fitting a cone cut further forward out of the bore, making a shot-chamber; the rear portion of the band of larger diameter is placed in a groove by itself, free to slide and rotate, and fits a cone—the original cone of the gun-chamber. This band is of such a shape as not to collapse or be crushed in on the shot being pushed into place. This sliding of the rear band allows of adjustment for any differences in manufacturing, and ensures perfect centering.

In firing to perfect my system, a curious fact, of interest to artillerists, established itself, and constitutes an important advantage for my system. It was found that the rifling twist at once communicates to the shot an accelerating gyroscope action, which has a tendency to strip, or at any rate diminish, the width of the impressions made on the driving-band, as in photograph, Fig. 6, of a shot with two fixed bands. This allows jets of high-pressure powder gas to pass, and is about the only damage done to the bore by erosion. The Admiralty contention that erosion alone is the cause of the excessive wear of heavy guns is entirely wrong, since erosion would wear both lands and grooves equally; whereas in the *Treatise on Service Ordnance*, 1904, page 630, it distinctly states the lands wear away.

With shot banded on my system, the rear band being free to revolve, the exact impressions of the rifling were preserved on the rear band (see photograph, Fig. 7); and further, on leaving the muzzle, this freedom to rotate prevents any disturbing influence acting on the projectile. The Ordnance Committee, Woolwich, by a long series of experiments, found that the driving-band was best placed as far to the rear as possible, for this very reason; so if two bands are employed on a shot, the rear one must be free to rotate.

In Fig. 5 I show a 6-in. projectile, with a single band, as at present used, lying in a shot-chamber of a gun converted to my system, and leaving the powder-chamber capacity unaltered. This gets over the question of using up old stores of projectiles, an objection raised against my system. The same drawing shows how the present system wears out the guns. It is not by erosion, but steel to steel, the hardened shoulder of the shot (the difference in diameters of shot and bore being 0.07 in new guns, throwing the axis quite ⅛-in. out of line) spluttering from side to side in its passage up the bore, knocking out bits at a velocity of 3000 ft.-seconds. The wear is in direct proportion to the weight of the shot on the square area. Thus a 6-in. gun—weight of

*Fig. 5.* **6 IN. GUN CHAMBER.**
*Converted to Stanbridge System with present Projectile.*




*Single banded Projectile; centring impossible, resting on bore,*
[illegible] *steel on steel, same position as unconverted gun chamber.*

1354

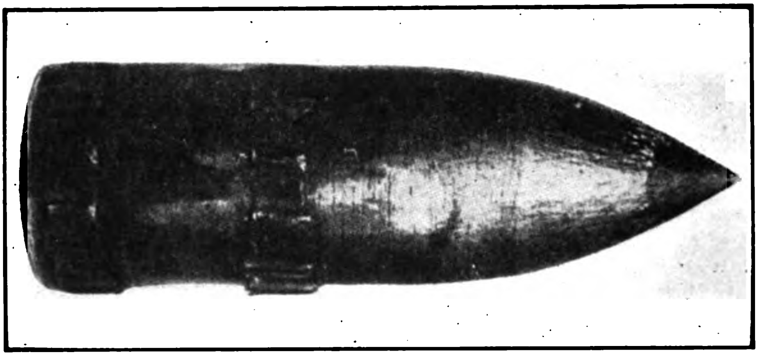


FIG. 6.

1355

FIG. 7.

1356

shot 100 lb.— wears out at about 350 rounds, against a 12-in. gun—weight of shot 850 lb.—lasting only 130 rounds. These figures are official (see *Treatise on Service Ordnance*, 1904, page 660).

Battleships, sometimes in pairs, are laid up to have the crown-plates of their barbettes torn off in feverish haste to get out the guns and change and reline them.

The French have already grasped this fact and formed a shot-chamber in their guns. Their projectiles have three narrow bands, which saves the wear of guns, but, of course, does not give true centering.

The U.S.A. (see report of the Chief of Ordnance, 1909, page 28) made a series of experiments, and have last year definitely adopted very wide bands, so as entirely to support and prevent the shot touching the bore. Again no true centering, but a change, although with a lot of drawbacks, the principal being the strain thrown on the gun and disturbance when the shot leaves the muzzle; the opposite of the French, three narrow bands.

Yours truly,

HENRY STANDBRIDGE.

Ivy House, Tinsley, Yorkshire. —*Engineering*.

## THE FRENCH BATTLESHIP *COURBET*

There is a striking similarity in the dimensions of the *Courbet* and the *Orion*. The former is 546 ft. long by 88½ ft. beam, while the British ship is 545 ft. long by 88½ ft. beam; but the draught for the French ship is given as 29 ft. for a displacement of 23,100 tons, with 900 tons of fuel on board, and for the British ship as 27½ ft. for a displacement of 22,500 tons, with the same weight of fuel on board. The French ship's Normand boilers and Parsons turbines are designed for 28,000 horse-power; the *Orion's* Babcock and Wilcox boilers and Parsons turbines for 29,000 horse-power, the corresponding speeds being 20 and 21 knots respectively.

The important difference has reference to the armament. In the *Orion* the British Admiralty stepped up from the 12-in. gun for the primary armament to the 13.5-in. weapon. The French still relied on the 12-in. guns; but whereas the *Orion* mounts ten primary guns, all in centrally situated barbettes, in order that all may fire on either beam, the French authorities fitted twelve 12-in. guns in six barbettes. As shown in the general view of the vessel [frontispiece] two of these barbettes are forward and two aft, while one is placed amidships on each side. The guns in the two turrets forward are mounted at different elevations, as is also the case with the two pairs aft, as shown in the general view * * * * . In this way there are available eight 12-in. guns to fire ahead in line of the keel, including the two pairs of guns amidship on each side, and eight to fire aft, with ten for broadside fire. In the *Orion* the same arrangement of guns at different elevations was introduced forward and aft, but there is only one central barbette, the two guns of which have a wide arc of training on each beam.

A striking feature of the *Courbet* is the power of the armament for repelling torpedo attack. Thus while the *Orion* was fitted with sixteen 4-inch guns, the *Courbet* has twenty-two 5.5-in. guns, in addition to four 3-pounder guns. She has thus a very considerable advantage in this respect. Moreover, she has four submarine torpedo-tubes, whereas the *Orion* and the other

seven ships of the same class have only three. The 5.5-in. guns are grouped in a somewhat interesting way. They are placed, as shown in the general view * * * , on the main deck in four batteries on each side. Forward alongside the main barbettes there are grouped on each side three of the guns * * * . Amidships, forward of the main barbette, on the port and starboard sides are three 5.5-in. guns similarly disposed, and firing ahead, with a considerable arc of training abaft the beam, while abaft the barbette on each side are three more guns firing aft, with a considerable arc of training before the beam; aft again, alongside the main after barbette, are two such guns. In this way it is possible to fire twelve of these guns ahead, eleven abeam, and ten astern.

The main belt of the *Courbet* is of 11-in. armor, reduced to 7 in. forward and aft, while over this is the protected deck of 3 in. The broadside, for a considerable length of the ship, has, on the strake above this main belt, 7-in. armor; the light guns are within armor of the same thickness. The armor of the main barbettes is 10½ in., and that of the gun-hoods 11 in. in thickness. The newer ships of the French Navy are mounting heavier guns, but many naval officers have, even still, a strong preference for a ship armed with such a numerous battery of 12-in. and 5.5-in. guns.—*Engineering.*

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## THE NEW FORTIFICATIONS OF THE COAST OF HOLLAND

Holland is beginning the execution of a plan which has for a long time been under consideration—the modernizing of its coast defenses. The history of the plan is as follows:

In order to have its coast defenses keep pace with naval progress, the government of Holland in 1910 submitted to the Second Chamber a project for improvement of coast defenses which called for 40,000,000 florins. Details of the project were contained in a joint note of the secretaries of war and of the navy: 25,000,000 were to be devoted to coast defenses, the remainder being applied to the procurement of floating defenses.

Toward the end of 1910 criticisms and counter-proposals were numerous: sometimes they concerned the location and the system of the proposed works; sometimes their armament. A committee designated by the Chamber collected those opinions—often very divergent—in a provisional report which appeared toward the middle of 1912.

In order to avoid further delay, the government, in its written response, deferred certain less urgent demands, and confined its main project to the following program:

1. Construction of an armored fort near Flushing.
2. Conversion of the obsolete fort of Kijkduin into a powerful modern fort.

(Both of these forts are to be armed with 11-inch, 45-caliber guns in armored cupolas.)

3. Increase of the fire effect of the armored forts of Hook van Holland, Ijmuiden, and Harssens by increasing the rapidity of fire and improving the ammunition.

The question of the part to be taken by the navy was eliminated from the proposed law. The expenditure necessary for the fortification of the

coast under the new program reached 12,000,000 florins. The government's memorandum also gave the details of the work done by its commission of enquiry which, for the purpose of acquiring information and making a choice of suitable material, had visited the works of Skoda, Krupp-Grusonwerk, Châtillon, Schneider, Saint-Chamond, Ehrhardt, Krupp-Essen, Armstrong, and Bofors.

The debates on the proposed law began in the Second Chamber in April, 1913. Besides being discussed from a political and financial point of view, the proposed law was discussed in all its technical details: principles of fortification of sea and land fronts; armored forts or open batteries, or even movable guns; obstructions; installation; indirect fire; considerations determining caliber; penetrating power and effect of burst; rapidity of fire; accuracy life of ordnance; the influence of the system of breech-block and ammunition; safety in action; probable tactical conditions and their influence on the opening, concentration, and control of fire, etc.—in short, all the important details of a project of coast defense were examined.

The advocates of the two systems of breech block—the screw with cartridge bag, and the wedge with metallic case—carried their contest even into the Chamber. It is understood that the choice has been given to the Krupp wedge system with metallic cased ammunition.

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## THERMIT INCENDIARY PROJECTILES

In an article published in *Zeitschrift für das gesamte Schiess-und Sprengstoffswesen*, the Austrian general, Tilschkert, advocates the use against men-of-war of incendiary projectiles filled with thermit. This substance, investigated by Dr. Goldschmidt, is a compound of powdered aluminum and oxide of iron; if ignited by suitable contrivance, liquid aluminum results, and the heat given off is sufficient to melt the free iron. The temperature of the mass is as high as 3000°.

Although modern battleships are almost entirely of metal, they are none the less liable to dangerous conflagrations, because of their very large supply of coal, oil, explosives, etc. And recent wars afford many instances of fires started by shell.* If, then, the gases resulting from the explosion of projectiles now in use, in spite of their maximum temperature of 900° and their extremely limited time of action, possess formidable incendiary properties, what would not be the effect of a mass of fused thermit, burning for several seconds and possessing a very much higher temperature—not only for immediately igniting combustible materials, but also for melting a steel armor plate and making for itself a passage through an armored deck?

One kilogramme of thermit liberates 3500 calories, while it may be assumed that about 220 calories are needed to raise one kilogramme of iron to the melting point.† Since a 12-inch shell can easily contain twenty-two kilogrammes of thermit, this mass will give out 99,000 calories, which, even

* At the battle of the Yalu (the China-Japan war), the *Chen-Yuen* had eight fires to put out; the *Ting-Yuen*, four; the *Yang-Wei* burned; etc. At the battle of Tsushima (the Russia-Japan war), conflagrations caused great damage aboard the Russian vessels; according to Semenof, the gases given off by the Japanese shimose shell had a temperature two thirds greater than the temperature of the gases of the Russian shell.

† The specific heat of iron is 0.1 at 0° and 0.2 at 1200°; if it be assumed as equal, between those limits, to 0.15, it is seen that 1500 × 0.15, or 225, calories are required to raise one kilogramme of iron to the melting point, 1500°.

assuming a loss of heat equal to 50 per cent, is sufficient to melt more than 200 kilogrammes of iron. Now, in order to open a hole of 15.5 square inches area in a plate 3.1-inches thick, it is necessary to melt only 6.5 kilogrammes. The liquid mass will then penetrate armored decks, and, flowing in together with the melted iron, will carry fire and devastation to the vitals of the ship.

—*Revue d'Artillerie.*

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## ILLUMINATING PROJECTILES

According to the *Militært Tidsskrift*, of Copenhagen, a captain of artillery of the Danish army has invented and successfully tested a device intended to supplement searchlights—or even to supplant them.

This device weighs only thirty-three pounds and can be carried and operated by one man, without special instructions. It throws a round bomb weighing about two and a half ounces a distance of 200 yards. These projectiles burst at a high altitude and throw out an illuminating mass which floats in the air for a length of time that can be varied from ten seconds to two minutes. The light which it sheds, coming from above, does not project, as do searchlights, shadows that render the terrain almost indistinguishable; but it lights up the terrain very distinctly for a distance of 300 yards from the projecting apparatus. The apparatus is ready for use in half a minute and can be placed behind cover, which gives it another advantage over the searchlight. The bombs can be thrown in all directions at a rate of seven to ten a minute.

In transportation and in handling they present no danger. Furthermore, both apparatus and projectiles are particularly inexpensive, in comparison with searchlights.

The disadvantage resulting from the fact that the projectiles render the position of those employing them visible, is compensated for by the fact that the light which they give out facilitates the use of the sights.

—*Les Archives Militaires.*

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## ILLUMINATING SHELL

A novel projectile which promises to be of great value in repelling torpedo attack at night is understood to have been adopted recently in the German Navy. This special shell is filled with calcium carbide. It is fired in the usual way, the range being equal to that of ordinary shells. On striking the water it sinks for a short distance, when the water, which enters through apertures in the body, sets up a chemical action and generates gas, the buoyancy of which drives the shell to the surface again. The gas is then ignited by an automatic device, and sheds a light equal in the large sizes, to 3000-candle power, which burns for about an hour. It is obvious that a number of these projectiles can be fired so as to form an illuminated zone round a ship or a squadron, thus rendering almost impossible the unperceived approach of torpedo craft. As an improvement on the star shell used by field artillery this new projectile is expected to have an important effect on night operations in naval warfare, and may prove a formidable enemy to the torpedoboat.

—*Naval and Military Record* in *Proceedings of the U. S. Naval Institute.*

## Short Notes

*Photographic Recording of Ballistic Phenomena with the Aid of the Quenched Spark.**—After a brief review of the methods used earlier for recording photographically rapidly-occurring processes, such as ballistic phenomena, the authors describe their method, which enables a regular succession of pictures to be taken of a single bullet fired from a pistol, on a falling photographic plate. A direct current quenched gap (of the Scheller type using alcohol) is used, connected to 700-volt mains. The capacity in the gap circuit is made up of mica condensers variable from 25,000 to 600,000 centimeters; the inductance is kept very low. This inductance and that of the secondary (equal to 1800 centimeters) are in the form of flat spirals so as to secure very close coupling. In the secondary is a small spark-gap (used to illuminate the object to be photographed) shunted by a condenser. The exposures are made on a film which runs over two drums of 89 centimeters circumference, capable of making 9000 revolutions per second. It is found that the number of sparks passing can be adjusted accurately to any number between 200 and 100,000 per second by (1) altering the capacity in the primary circuit; (2) regulating the intensity of the current in the primary. Reproduced photographs show the method's capabilities. With 6400 sparks per second, the firing of a shot at a piece of wood is seen in all its phases. With 10,000 sparks per second, the movements of the cartridge in the operation of an automatic pistol can be followed. Other records show the bullet issuing from the muzzle, and the accompanying phenomena, taken with spark frequencies of 56,200, 72,000 and 92,200 per second. The possible application of this method to investigate electric double refraction is also mentioned.

—*Journal of The Franklin Institute.*

*Modern Heavy Coast Defense Guns.*—Captain Pappalardo, in the *Rivista d'Artigleria,* discusses the relative advantage of 12-inch and of heavier calibers for coast batteries. He holds that the percentage of hits obtained depend less on the accuracy of the gun than on observation and correction of fire. But since observation is difficult at 8800 yards and almost impossible at 13,000 yards, the longer range obtained with the 13-inch or 14-inch gun is of no value. In the United States it is laid down that a coast battery should only fire a few single shots between 12,000 and 8000 yards; between 8000 and 4000 heavy losses may be inflicted with the big guns: and from 4000 downwards these will be capable of piercing the armor, while the medium and small guns will also do serious damage. The cost of heavy guns is a big item; in Italy a coast battery costs £185,000 for four 12-inch guns, each with 100 rounds, besides £64,000 for the battery. A battery of 12-inch howitzers can be obtained for half the cost, and the prospect of effective hits is considerably greater. Moreover, the howitzers maintain their accuracy much better than the guns, which may be worn out by a single days fighting.

—*The Journal of the Royal Artillery.*

*British Coastguard and Naval Airmen.*—This year's maneuvers have disclosed not only the great utility of the Naval Wing of the Royal Flying Corps, but the necessity for pushing on as fast as possible with the completion of the aviation stations around our coasts and the selection of sites and creation of fresh aerial centers for coast defense, at the earliest possible

* C. Cranz and B. Glatzel. (*Deutsch. Phys. Gesell.*, xiv, 10,525.)

moment. A crinoline of aerial stations is, in fact, permanently embodied in the scheme of our ring fence of coast patrol and protection; and will be as much in evidence as a naval feature of our watch and ward on the shores of the United Kingdom as are the ubiquitous coastguard stations which stretch on either side of our coasts from John-o'-Gróats to Land's End. It would not be at all surprising if a gradual process or evolution shortly began which will end in the Flying Corps absorbing the whole of the coast duties by a process of expansion, the coastguards and airmen becoming merged into a common corps for coast defense under captains or flag officers appointed to command districts, much in the same way as Coastguard Commands are now arranged. At any rate, the coastguards and naval airmen along the coasts will always have to closely co-operate in their work in general, and, in isolated places, be in close social association, if the amenities of life are to be maintained by men detached for patrol duties along the wild parts of our rock-bound shores.—*United Service Gazette.*

*British Experiment in Manning Coast Defenses with Marines.*—Heretofore in England fixed coast defenses have been wholly in the hands of the army; so it is interesting to note an exception to the rule which is about to be made experimentally.

The defense from attack from the sea of Cromarty Firth will be turned over to the navy, and the batteries now being built on both sides of the entrance, which it is hoped will be completed before the close of 1913, will be manned by marines. An old ship, probably the *Renown*, will serve as barracks.—*Revue Maritme.*

*Defense Against Aeroplanes in Great Britain.*—A new type of rapid fire gun, intended to attack dirigibles and aeroplanes, is to be adopted. Two models are contemplated: the one light, the other heavy. The first, mounted on a turn-table, seems designed for use in aeroplanes and (especially) in dirigibles for fighting other aeroplanes and dirigibles. The second is a more powerful arm, of very rapid fire, capable of being used at all angles of elevation, and constructed to defend frontiers, approaches to fortresses, and arsenals against hostile aerial forces, and to repel attacks directed against a fleet.—*Le Yacht* (Paris).

*Defense Against Aeroplanes in U. S.*—Instead of developing a special gun for a defense against aeroplanes the Ordnance Department has decided to modify its types of field guns and carriages so that all of the guns in the future will be able to attack aeroplanes. Preliminary work in this direction has been done in experiments with the Deport gun, which has a split trail and recoil system, especially adapted to firing at a high angle. For over a year the officers of the Ordnance Department of the Army have been experimenting with the Deport gun and have developed some ideas which it is thought will secure a new type of field gun superior to the French gun, and one which will solve all of the problems connected with firing at aeroplanes. Experiments have progressed to that point at which firing has been done at an angle of forty-five degrees, and it is thought that the new type of field artillery gun can be fired successfully at a ninety degree angle. This can be accomplished through the split trail and a modification of the recoil system. It will also be necessary to make some changes in the gun as well as the carriage of field artillery. The new gun, in addition to increasing the angle at which field

artillery can be fired, will give greater range horizontally. Without moving the carriage the gun can be fired laterally at a greater angle than with the present trail. This is due to the fact that a split trail will act as a sort of brace for the gun on a wider angle than the present trail. It is understood that an order will shortly be issued to the Watervliet Arsenal for the construction of an experimental carriage for the new type of field gun.

—*Army and Navy Journal.*

*German Coast Artillery.*—An imperial order has just been issued which increases by one company the 3rd (Lehe) group of marine artillery and the 5th (Helgoland) group of marine artillery. These two groups will hereafter, therefore, consist of three companies. The 1st (Friedrichsort) and 4th (Cuxhaven) groups each comprise five companies, and the 2nd (Rüstringen and Wilhelmshaven) group only four companies. After the imperial order cited goes into effect, the marine artillery (*Matrosenartillerie*) will comprise in all twenty companies organized in five groups, one for the Baltic and four for the North Sea. The coast fortifications of Borkum will be garrisoned, not by marine artillery, but by foot, or fortress, artillery of the army; and, with the exception of Kiel, the same will be the case with the coast batteries of the Baltic Sea.—*Les Archives Militaires.*

*A New German Torpedo.*—A new 21.6-inch automobile torpedo is just being issued. Its extreme effective range is 7500 yards and its speed 29 knots. The speed is low for such a range, but on the other hand the charge can be as great as 287 lbs., which is enormous. The test of the new torpedo has demonstrated a destructive effect much superior to the effect of the former 19.6-inch torpedo. The new torpedo will be issued to ocean-going torpedo-boats.—*Le Yacht* (Paris).

*Exploding Mines by Wireless.*—An Italian engineer, Uliyi by name, is reported to have devised a method of exploding submarine mines at a distance of several miles by means of wireless impulses. According to the dispatch, Major Ferrie, head of the Eiffel Tower Wireless Telegraph Station, was present at an experiment in which Uliyi succeeded in exploding mines at a distance of 15 miles. Although it is true the application of wireless to warfare of this kind has been made the subject of much serious experimental work, we confess to considerable skepticism as to the results obtained.

—*Scientific American.*

*The Five British Battleships of the 1913-1914 Program.*—The new battleships will differ very noticeably from those of the *Queen Elizabeth* class. They will burn coal, oil being used only as an auxiliary in case of necessity; the designed speed will be reduced from 25 to 21 knots, in order to permit of a reduction of 2000 tons in displacement without affecting in the least the ships' offensive and defensive qualities. The reduction in displacement is obtained principally by a very considerable reduction in beam; and it is hoped that, in comparison with the *Queen Elizabeth* class, the cost of their successors will be lowered by 13 or 14 per cent.—*Le Yacht* (Paris).

*Japanese Naval Artillery.*—It seems to be corroborated that twenty-eight 14-inch pieces have been ordered of Vickers for the battle cruisers of the *Kongo* class. The other pieces are being manufactured in Japan at the

Muroran gun factory, which is equipped for building 15-inch and 16-inch guns, though guns of such large caliber have not yet been built there. The management of the shops, expecting to be able to get along without the assistance of the English experts, had retained only a small number of them, following therein the practice which had obtained in Japan for a long time —that is, of dispensing, as far as possible, with the help of foreigners. But in the face of the disturbing number of articles rejected on account of bad workmanship (more than half, it is said), it has just been decided to have engineers and foremen again come from England in such number as to raise the European personnel to forty.

The three new battleships which have just been ordered will probably carry 15-inch guns. There is also talk of making a 14.5-inch caliber.

—*Revue Maritime.*

*German Ships. Shipbuilding Progress.* The four armored ships of the 1911 program have been launched since January. The battleship known as "S" took the water on March 1 from the Imperial dockyard at Wilhelmshaven, and was named the *König*. The "Ersatz-Kurfürst Friedrich Wilhelm" was launched on May 5 from the Vulkan yard at Hamburg and named the *Grosser-Kurfürst*. The "Ersatz-Weissenburg" was put afloat on June 4 at the Weser yard, Bremen, and named the *Markgraf;* and the battle-cruiser "K," built at the yard of Messrs. Blohm and Voss, Hamburg, after an unsuccessfulattempt at launching on June 14, eventually took the water on July 1, when she was named the *Derfflinger*. The armament of the three battleships is understood to include ten 14-in. guns, fourteen 6-in., and twelve 3.4-in. guns, and their displacement is stated to be about 26,500 tons. No authentic information about them, nor about the battle-cruiser, was published on the occasion of the launches. These four vessels increase the total of German Dreadnoughts afloat to 21, of which 16 are battleships and five battle-cruisers. The *Kaiserin* and *Seydiltz*, of the 1910 program, were undergoing trials in May.—*Journal of the Royal United Service Institution.*

*Triple-Gun Turrets in Italy.*—Both triple and twin turrets figure in the design of the *Dandolo* and *Morosini*, laid down in December, 1912, by the firms of Ansaldo and Odero, in which Messrs. Armstrong, Whitworth and Co., and Messrs. Vickers, Ltd., are respectively interested. Each vessel will carry ten 14-in. guns, arranged in two triple and two twin turrets on the keel line. In the next battleships laid down, however, it is stated that the triple turret method will not be followed. According to a dispatch from the Rome correspondent of the *New York Herald* (European Edition), published on June 15, the Italian Admiralty, which initiated the triple-gun turret for the *Dante Alighieri* in 1909, has now definitely abandoned it, and the four battleships laid down this year will have only two big guns mounted in each turret. The same writer states that firing practice with the *Dante Alighieri's* guns showed that when two contiguous guns were fired in a triple-gun turret the turret was often put out of working order. It has been decided that the four new ships, which are to be completed in 1916, will be of 30,000 tons displacement, 25 knots speed, and will carry eight 15-in. and twenty 6-in. guns, with a maximum thickness of 12 inches of armor.

—*Journal of the Royal United Service Institution.*

# BOOK REVIEWS

**Une Etude sur l'Efficacite du Tir (A Study of Fire Effect).** By Commandant Treugier. Paris: Librairie Chapelot, 30 Rue Dauphine. 5½" x 9". 35 pp. 6 il. Paper. 1913. Price, 0 fr. 75.

This is a brief discussion of the effectiveness of shrapnel fire from field artillery against infantry, as a function of the angular height of burst and as a function of the range setting with respect to the target.

The discussion avoids the common error of considering only a fixed trajectory with points of burst located at different points on the trajectory: it considers also the sheaf of trajectories, thus introducing the dispersion due to this cause. The result is at variance with the conclusions based on the less exact hypothesis.

This gives an added interest to the conclusions drawn, which are as follows:

a. A height of burst of 1 mil is the best for all purposes.

b. Against a visible target, the range setting should be such as to cause the *trajectory* to pass through the target. Fire at a fixed target should be executed on the 50-meter fork.

c. "Walking" through a zone, by salvos or *rafales*, gains in effectiveness when a step of 50 meters is used, as distinguished from a step of 100 meters. The range settings should in no case be for a range nearer the battery than the hither limit of the zone.

d. As a measure of security, it is desirable to avoid using a range greater than that of the target.

e. The *greatest* range to be used, for effective shrapnel fire at a visible target, is the further limit of the fork diminished by 50 meters.

The pamphlet is interesting as presenting one side of a question which is important to the field artillery.

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**Tir pratique a l'usage des officiers de reserve et des sous-officiers d'Artillerie** (Practical gunnery for officers of reserves and non-commissioned officers). Paris: Berger-Levrault, Rue des Beaux-Arts, 5-7. 4¼"x7¼". 109 pp. 43 il. Paper. 1913. Price, 2 fr.

The purpose of this handbook and its method are stated in the following quotations from the preface: "While a very large number of artillery officers are masters of gunnery, yet in war there will be fatalities amongst them; so it must be remembered that our comrades of the reserves of the territorial army and our non-commissioned officers will often succeed to commands of considerable importance. It is for these that this little volume sets forth the principal articles of the regulations and endeavors to make them clearer by the use of numerous figures."

"We shall, therefore, take a battery as it comes into position and follow it in all its operations as they are successively performed."

The text begins with the orders of the major, then presents the duties of the captain, discussing reconnaissance, defilade, pointing the directing gun, establishing gun differences, observation of fire, ranging, and the various incidents and phases of fire against an enemy—time-fuze practice, use of shrapnel, etc.

Twenty-seven pages are devoted to examples, in which are given a situation, an estimate, and orders; then follow three appendices, one on the use of the mil, one on definitions and the characteristics of the piece and the trajectory, and one on fire effect.

The book must prove useful for the classes for whom designed and it will serve, as well, as a convenient résumé for proficient artillerists.

*Photograph by Stephen Cribb, Southsea.*

SHIP TO SHORE OPERATION



Exhibition of British naval drill in taking field-gun, limber, and men over a 30-foot chasm, at the Naval and Military Tournament in London, May 21th to June 30, 1913

# JOURNAL

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*"La guerre est un métier pour les ignorans
et une Science pour les habiles gens."*

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## A SUGGESTED FORM OF PRESENTATION OF THE DRILL FOR THE 10-INCH OR THE 12-INCH GUN ON A DISAPPEARING CARRIAGE.

BY CAPTAIN CLARENCE B. SMITH, COAST ARTILLERY CORPS

The service of the piece has been materially changed since the publication of the Coast Artillery Drill Regulations of 1909; so it has been found convenient by the writer to prepare for his own use a revision of the drill in which are incorporated all authorized changes. And experience in instructing officers of Coast Artillery Reserves having convinced the writer that our present coast artillery drill regulations, while admirable in many respects, are too complicated to be readily grasped by one inexperienced in coast artillery procedure, it has appeared advisable to employ a form of presentation of the drill that would render it less difficult for the reserve officer. It is with that object, then, that the drill is here presented.

By arranging the duties in sequence of time it is believed that it is made much less difficult for the uninitiated to coordinate the work of the different members of the gun detachment.

The drills for the 10-inch and 12-inch guns on disappearing carriages being so similar, an effort has been made to write a drill that can be made applicable to either.

The drill regulations have been closely followed, only such changes being made as are necessitated by amendments to the regulations themselves, by the 1913 Regulations for the

Instruction and Target Practice of Coast Artillery Troops, and by the desire to assign the same numbers to the members of the powder serving details of the two calibers. For the last mentioned purpose the most important departure from the drill regulations consists in assigning to the cannoneers who perform in the 12-inch gun drill the duties of Nos. 16, 18, and 17, respectively, the new numbers 20, 21, and 22.

In the drill as here presented portions of the text in smaller type are explanatory or are of only occasional application; cannoneers indicated by numerals enclosed in parentheses are for the 12-inch gun only and are for the 12-inch gun with either the 1888 model breech mechanism or the 1895 model (Stockett) breech mechanism; duties of cannoneers indicated by numerals enclosed in parentheses and italicized, apply only to the 12-inch gun with the Stockett breech mechanism.

The drill follows:

## Gun Section

For the service of the 12-inch gun on a disappearing carriage the following are required:

(a) 1 gun commander (n.c.o.; generally a sergeant).
(b) 1 gun pointer (n.c.o. or private).
(c) 1 range setter (n.c.o. or private).
(d) 1 range recorder (n.c.o. or private).
(e) 1 deflection recorder (n.c.o. or private).
(f) 1 chief of breech detail (n.c.o. or private).
(g) 22 privates numbered from 1 to 22.
Total, 28 enlisted men.

For the 10-inch: (a), (b), (c), (d), (e), and (f) above and 19 privates numbered from 1 to 19. Total, 25 enlisted men.

### DETAILS AND POSTS

The gun section is divided into details and posted as follows:

*Gun Commander:* On the gun or loading platform. He goes wherever necessary.

*Gun Pointer:* On the sighting platform.

*Range Setter:* At the range scale.

*Range Recorder:* At the time-range board.

*Deflection Recorder:* At the deflection recorder's board.

*Breech Detail:*

Chief—Two yards in rear of breech, facing breech.

No. 1—One yard to right and rear of breech, facing breech.

No. 2—One yard to left and rear of breech, facing breech.

No. 3—One foot to the right and front of elevating band, facing to the rear.

(For the 12-inch gun, add No. 22 whose post is two feet to the right of the breech on line with its face, facing breech.)

*Rammer Detail:*

No. 4—Near platform rail, two yards from head of rammer, within reach of staff, facing the gun.

(For the 12-inch, add Nos. 20 and 21, who take post 4 yards to the left and right respectively of No. 4, in line with him, facing the gun.)

*Elevating Detail:*

Nos. 5 and 6—At left elevating handwheel near range scale, No. 5 nearest the muzzle.

*Traversing Detail:*

Nos. 7 and 8—At the traversing crank on the same side of the piece as the sighting platform, facing the gun pointer, No. 7 to the left of No. 8.

*Tripping Detail:*

No. 9—At the right tripping lever.

No. 10—At the left tripping lever.

*Truck Detail:*

Nos. 11 and 12—At a loaded truck. No. 11 at the right handle, No. 12 at the left.

*Powder Serving Detail:*

Nos. 16 (chief), 17, 18, and 19 at powder serving tray near the powder hoist, Nos. 16 and 18 on the left, Nos. 17 and 19 on the right.

*Hoist Detail:*

No. 13 (chief)—At delivery table of ammunition.

Nos. 14 and 15—At hoist.

Cannoneers are numbered from breech to muzzle. The *odd* numbers are posted on the *right* of the piece and the *even* numbers on the *left*, when facing the muzzle, with the exception of the elevating and traversing details as noted above.

### TO POST CANNONEERS

When near the battery, the officer in charge of a company commands, *SECTIONS, POSTS;* each chief of section marches his section to a point near its station, halts it, and commands, *DETAILS, POSTS;* the members fall out and obtain the implements and equipment from the store room and take their posts.

IMPLEMENTS AND EQUIPMENT

The cannoneers procure equipment as follows:

The Gun Pointer—A telescopic sight.

The Range Setter—(1) A stop watch; (2) an abridged range table.

No. 1—(1) A handful of cotton waste; (2) an oil can containing engine oil; (3) a hand sponge for spreading oil.

The can and sponge are placed convenient to the breech; the cotton waste is carried in the coat pocket or in the belt.

No. 2—A handful of cotton waste.

The cotton waste is carried in the coat pocket or in the belt.

No. 3—(1) A lanyard; (2) a primer pouch; (3) a holder containing a punch and drill; (4) the firing mechanism.

No. 22—If 12-inch gun with Stockett breech mechanism, No. 22 procures the operating crank. At some batteries it is customary to keep the translating roller for the 1888 model breech mechanism in the store room, in which case No. 1 procures this roller.

No. 4—The rammer.

At a 12-inch battery No. 4 is assisted by No. 21.

No. 5—The chamber sponge.

No. 6—The extractors for the dummy projectile.

Nos. 7 and 8—The traversing cranks, and place them on the traversing shaft.

The traversing cranks are usually hung on hooks on the side of the chassis.

No. 9—(1) A filling-plug wrench; (2) a measure of hydrolene oil; (3) a funnel.

No. 10—(1) A filling-plug wrench.

Nos. 11 and 12—The shot trucks, and turn them over to hoist detail for loading. When the first truck is loaded they run it to the "loading position."

The "loading position" is with the truck well back to the right or left rear of the gun near the hoist from where it can be run forward readily at the command *LOAD* or *COMMENCE FIRING*.

Nos. 13 and 14—The bore sponge and extension staff.

Hooks attached to the platform rail in rear of the gun are usually provided for the rammer and sponges. If not, and the rammer prop is used, it should be brought up by No. 2. *Rammer and sponges are habitually placed with the head toward the ammunition hoist.* In this position they can be handled more conveniently. Extractors for dummy projectiles are usually laid on the gun platform under the rammer, if there is not room on the hooks for them.

No. 15—The retraction cranks, and places them on the hooks.

### TO EXAMINE GUN

Equipment having been procured and placed and the cannoneers posted, the Gun Commander commands, *EXAMINE GUN.*

No. 1 (and No. 22) removes the breech cover and places it out of the way. Nos. 1 and 2 (or *No. 22*) open the breech. The chief of breech detail examines the breech mechanism, breechblock, breech recess, chamber, and bore, and gives the necessary orders for putting them in condition. If the chamber needs sponging, the chief of breech detail calls for the chamber sponge, which is brought by No. 4, and assisted by Nos. 1, 2, 3, 4 (and 22), he sponges the chamber. If the bore needs sponging, it is done by the chief of breech detail and Nos. 1, 2, 3, 4, 5, 6, 7, 8, (and 20, 22).

No. 1 (and No. 22) cleans and oils the breechblock and mechanism.

No. 2 cleans and oils the breech recess and gas check seat.

No. 3 examines: (1) the safety lanyard device; (2) the firing mechanism; (3) the long and short lanyards; (4) the vent and primer seat. He coils the long lanyard and hangs it over the end of the elevating arm. He clears the vent when necessary and cleans the primer seat.

(1) To examine the safety lanyard device, the pawl is held free from the ratchet and the safety lanyard pulled out its full length. The pawl is then released and the safety lanyard should run back freely into its housing. (2) To test the firing mechanism, translate the breechblock; hook the lanyard to the firing leaf and pull steadily on the lanyard while the block is being rotated. There should be no raising of the firing leaf until the breechblock is completely rotated. (3) Free the long lanyard of kinks; hook one end of the short lanyard to the firing leaf and the other end to the ring of the safety lanyard, with the breechblock closed. It should be long enough to reach freely without sag. (4) The vent is cleared by inserting the punch or drill *from the mushroom head end of vent only;* the primer seat is cleaned with the reamer or brush provided in the firing mechanism box.

The Gun Pointer: (1) examines the sight; (2) tests the traversing mechanism assisted by Nos. 7 and 8; (3) verifies adjustment of azimuth index; (4) tests the electric firing circuit.

(1) Examine sight and adjust it for clear definition by means of the eye piece adapter and the focusing collar or knob. (2) Have the gun traversed by Nos. 7 and 8 to see that it moves freely. (3) Have the gun traversed and the azimuth index set at the azimuth of some known datum point. With the deflection scale of the sight set at normal the vertical wire of the sight should bisect the datum point. The azimuth index is dowelled and cannot slip. If the vertical wire of the sight does not bisect the datum point, the sight is out of adjustment and the gun should be bore-sighted. (4) The safety switch of the firing circuit should be connected with a short

length of copper wire and a service primer inserted. When the gun pointer presses the button which closes the testing circuit there should be a buzzing sound. If there is none, look for a fault in the dry cell battery or a short circuit in the firing mechanism due to too much oil. When a magneto is used instead of the dry cell batteries, insert an electric primer, connect the safety firing switch with a short length of wire, if the gun is from battery, and have No. 9 (or 10) attempt to fire the primer by operating the magneto. If the primer fails to fire, examine the magneto to see that it generates properly; also look for a short circuit in the firing mechanism due to an excess of oil on the mechanism.

Nos. 5 and 6 assist the range setter in testing the elevating and retracting mechanism and in cleaning and oiling the gears. They assist in sponging the bore.

Nos. 7 and 8 remove the drip pans. They assist the gun pointer in testing the traversing mechanism. They assist in sponging the bore. No. 8 receives the muzzle cover from No. 11 (21) and puts it out of the way.

Nos. 9 and 10 remove filling plugs; if necessary, fill cylinders and replace plugs. No. 11 (21) passes the funnel and oil measure to No. 9, if they are called for, and replaces them. After filling the cylinders, No. 9 (or 10) assists the gun pointer in testing the electric firing circuit, if a magneto is used, and then takes post, facing the gun, near the platform rail, No. 9 one yard to the right of No. 4 and No. 10 one yard to the left of No. 4. (For 12-inch gun this interval is increased to 3 yards.)

No. 11 (21) removes the muzzle cover and passes it to No. 8 who puts it out of the way. No. 11 (21) passes the funnel and measure of hydrolene to No. 9 when the recoil cylinders are filled, receives them back and puts them aside.

Nos. 11 and 12 examine the trucks and clean and oil them.

Nos. 13, 14, and 15 examine and clean the delivery table of ammunition hoist.

Nos. 16, 17, 18, and 19 examine the powder serving trays and see that they are in good order.

The Range Recorder tests the gun telephone and range transmission apparatus.

The filling plugs of both recoil cylinders should be removed, if any filling is to be done, to avoid the formation of an air cushion. No. 9 pours the oil into the right cylinder slowly, while No. 10 watches the oil hole in the left cylinder and notifies No. 9 when the cylinders are full. No. 9 in turn notifies the gun commander who then inspects the cylinders. The filling plugs are replaced and Nos. 9 and 10 take their posts.

The Gun Commander makes a general inspection of the gun and carriage paying particular attention to the throttling valve, recoil cylinders, and the oiling of the various bearings.

In this inspection he is accompanied by a mechanic with an oiler. No formal report is made to him of the examination by the various details. Any defects found are reported to the gun commander promptly by the cannoneer who discovers them. The gun commander reports to the emplacement officer, "Sir, No.———in order," or reports defects which he is unable to remedy without delay.

### TO OPEN BREECH, MODEL 1888 MECHANISM

No 2 releases the rotating crank by throwing the lever of the safety lock and then turns the rotating crank clockwise, as indicated by the "open" arrow, until it brings up short in a horizontal position and is secured by its catch. No. 1 turns the translating crank briskly contra-clockwise. When the shoulders of the grooves strike against the ends of the rails, the block stops short and the shock frees the tray latch from its catch; No. 1 swings the tray and block to the right until the securing latch engages in the catch.

### TO CLOSE BREECH

No. 2 releases the securing latch from its catch; No. 1 swings the tray and block around to the left smartly; No. 2 seizes the handle of the tray and continues the swinging of the block until the tray abuts against and is latched to the face of the breech; then he turns the translating crank clockwise until the breech is translated completely; No. 1 releases the rotating crank, by throwing the lever of the safety lock, and turns the rotating crank contra-clockwise, as indicated by the "close" arrow, until it brings up short in a vertical position and is secured by its catch.

### TO OPEN BREECH, MODEL 1895 MECHANISM

The chief of breech detail unhooks the lanyard from the eye of the firing leaf; No. 22 (No. 3 for 10-inch) turns the crank continuously in a clockwise direction until the tray comes to rest against the hinge plate and the securing latch catches.

### TO CLOSE BREECH, MODEL 1895

No. 1 releases the securing latch and turns the crank in a contra-clockwise direction until the projecting shoulder on the rotating lug striking the gear prevents further motion. The latch should be released before the truck is withdrawn from

the breech, holding the breechblock open by the operating crank until time to close it.

### TO LOAD OR COMMENCE FIRING

The battery commander indicates the target, designates the kind of projectile to be used, and commands:

(1) *NO.———, FIRE —— ROUNDS; COMMENCE FIRING.*

(2) *FIRE———ROUNDS; COMMENCE FIRING.*

(3) *COMMENCE FIRING.*

A round is a single charge of ammunition (powder and projectile) for a gun or mortar. Any of the above commands may be preceded by the command, *NO* ——, *LOAD* or *BATTERY*, *LOAD*.

At either command, the indicated gun or all the guns of the battery are loaded but *not* tripped. The lanyard is *not* hooked. The command *FIRE —— ROUNDS*, means that the indicated gun or all the guns of the battery are each to fire the specified number of rounds. The command, (3) *COMMENCE FIRING*, when *not* preceded by any other command means that the firing is to be taken up at once by all the guns of the battery and is to be continued until the command *CEASE FIRING.* When preceded by a command limiting the number of rounds, it means that the firing is to be taken up at once by the indicated gun or all the guns and continued until the specified number of rounds has been fired.

Any time after the command *COMMENCE FIRING* has been given, loading or firing is suspended by the command *CEASE FIRING.* If the piece has been loaded, lanyards will be detached; if firing by electricity, the firing circuit will be broken. Cannoneers remain at the posts they occupied at the command *CEASE FIRING.* If firing is not to be resumed, fixed ammunition and separate cartridges will be withdrawn. Projectiles *not loaded* and *fused* will be driven back and withdrawn. Projectiles *loaded* and *fused* will be left in the guns until a favorable time to fire them; *on no account will an attempt be made to drive them back.*

The battery commander having designated the kind of projectile to be used and having commanded *LOAD* or *COMMENCE FIRING*, the gun commander repeats to the truck and hoist details the kind of projectile to be used and commands, *NO.* ——, *LOAD*, or *NO.* ——, *COMMENCE FIRING.* The command *LOAD* is executed in the manner prescribed in the following paragraph, except that when the truck is withdrawn and the breech closed, the chief of breech detail gives the command *HALT*, and not *IN BATTERY, TRIP.*

*To Load and Fire:* A shot is supposed to have just been

fired. The cannoneers are at the posts they would occupy at the instant of discharge. No. 3 is well back to the right and rear of the breech with lanyard extended; the chief of breech detail is four feet in rear of the breech; (No. 22 is near operating crank of breech mechanism); the truck is at the loading position.

At the command *LOAD* or *COMMENCE FIRING* the following is done in the order shown, without further command: The chief of breech detail springs in and unhooks the short lanyard; Nos. 1 and 2 (*No. 22*) open the breech (NOTE: at a 10-inch gun with Stockett breech mechanism No. 3 opens the breech); No. 4 runs up with a damp chamber sponge. The chamber is sponged by Nos. 1, 4 (and 22) on the right of the sponge staff; No. 2 and the chief of breech detail on the left. The sponge is withdrawn and replaced by No. 4. The mushroom head is wiped off with a damp cloth by No. 1 (No. 22).* No. 4 seizes the rammer at its balance (assisted by Nos. 20 and 21); Nos. 11 and 12 run up a loaded truck. As the truck passes the rammer detail, the rammer detail brings the rammer in prolongation of the projectile on the truck. Nos. 9 and 10 seize the rammer with both hands.

For the 12-inch gun Nos. 9 and 10 take post on the rammer in front of Nos. 20 and 21, who are as far to the rear as possible. On the 10-inch gun Nos. 9 and 10 take post on the rammer as far to the rear as possible.

No. 1 seizes the rammer about four feet from its head and guides the rammer head against the base of the projectile.

For the 12-inch gun with 1888 model breech mechanism No. 22 guides the head of the rammer in the place of No. 1, who does not assist in ramming.

No. 2 takes his place on the rammer in front of No. 10. The men on the rammer follow the truck, all taking a firm hold of the staff with both hands, Nos. 1, 4, 9 (and 21) on the right, Nos. 2, 10 (and 20) on the left of the rammer.

This drill is written for a battery with the ammunition served from the left. Were the ammunition served from the right, Nos. 1 and 4 would be on the left of the rammer, since the rammer is always placed on its hooks with head toward ammunition hoist. No. 4 would be on the left of the sponge staff in sponging for the same reason.

As soon as the truck brings up against the face of the breech the men on the rammer push the projectile carefully off the truck until the projectile is just inside the powder chamber. The truck is quickly withdrawn by Nos. 11 and 12 to the left rear and returned to the delivery table for reloading. Nos. 11 and 12 then take post at a loaded truck. As soon as the truck is out

* Par. 652, C. A. D. R. as amended.

of the way the chief of the breech detail commands *HEAVE* and the men on the rammer run forward and seat the projectile with one motion, using the greatest possible force. As the truck is clearing the breech after the projectile has been launched, the powder serving tray containing the powder charge is "edged-in" from the left rear by Nos. 16, 17, 18, and 19, and as soon as the rammer has been withdrawn after seating the projectile, the nose of the powder tray is inserted in the breech by the powder servers, and the ramming detail, with one motion, carefully pushes the entire powder charge off the serving tray into the chamber. As soon as the powder charge has been pushed home, the rammer is quitted by Nos. 1, 2, 9, and 10. Nos. 1 and 2 prepare to close the breech; Nos. 9 and 10 run to the tripping levers and take hold of them ready to trip. No. 4 (assisted by Nos. 20 and 21) withdraws the rammer, replaces it and stands by for the next shot. The powder servers withdraw the powder tray, return it to the powder hoist, and stand by for the next shot. When the powder tray is withdrawn, the breech is closed by Nos. 1 and 2 (No. 1 assisted by No. 22). During the loading No. 3 coils the long lanyard and serves the vent. When the breech is closed No. 3 inserts the primer.

The chief of breech detail hooks the lanyard to the eye of the firing leaf and commands *IN BATTERY*. The gun commander verifies the setting of the range scale and calls *SET*, after which the chief of breech detail commands *TRIP*. Nos. 9 and 10, at the command *TRIP*, raise the tripping levers smartly to their stops and run to their posts at the rammer for the next loading.

If the piece is fired electrically, No. 10 waits till the gun is fully in battery and closes the safety firing switch. And if a magneto is used he fires the piece at the command *FIRE* of the gun pointer.

No. 3 steps back to the right and rear as the gun goes into battery, letting the long lanyard uncoil.

The elevating and traversing details remain at their posts throughout the service of the piece. As soon as the truck is withdrawn from the breech, the gun pointer directs the traversing of the piece so that the gun will be pointed at the target by the time it is fully in battery. The gun commander notes whether or not the gun goes fully into battery.

If the gun fails to run fully into battery Nos. 9 and 10 (and 20 and 21) force it up the remaining distance, using the pinch bars in connection with the fulcrums on the forward ends of the chassis rails and the ratchets under the outer clips of the top carriage.

The range setter and the gun commander both note whether any change takes place in the range setting by the gun's going into battery; if there be any material change, the range setter will restore the right setting instantly, under the supervision of the gun commander. As soon as the setting has been verified by the range setter and the gun commander, the gun commander calls *READY*, after which the gun pointer commands *FIRE*, as soon as he has the piece properly pointed. If firing by electricity, the gun pointer closes the firing switch at the time he commands *FIRE;* if a magneto is used, No. 10 fires the piece at the command *FIRE* of the gun pointer. If not firing by electricity, No. 3 pulls the lanyard with a strong, quick pull at the command *FIRE*, of the gun pointer. As soon as the gun recoils, the chief of breech detail springs in and unhooks the short lanyard, the block is opened and the operations described above are repeated.

The foregoing explains the loading and firing of all shots after the first one. For the first shot the command *LOAD* or *COMMENCE FIRING* must be given. The chamber is not sponged prior to the first shot. The breechblock may be open before the command *LOAD* or *COMMENCE FIRING* is given.

### TO UNLOAD

The gun commander commands *UNLOAD*. The breech is opened. No. 3 removes the primer. Nos. 16, 17, 18, and 19 bring up an empty powder serving tray. No. 4 brings up the extractor and pulls the dummy powder sections back on to the powder tray. Nos. 11 and 12 run up an empty truck after the powder tray has been removed. No. 4 (assisted by Nos. 20 and 21) withdraws the dummy projectile and replaces the extractor. Nos. 11 and 12 return the truck to the loading position. The breech is closed.

### FIRING DATA

The range recorder and deflection recorder are connected by telephone with the plotting room. The range recorder receives and plots the ranges received on the time-range board. The deflection recorder calls out the deflections to the gun pointer and posts them on the deflection recorder's board. The gun pointer sets the deflection scale of the sight at the deflection called or posted. In practice no ranges will be set on the range scale of the gun until the gun is about to be trip-

ped. The range setter then decides upon a time a few seconds in advance when the piece will be in battery ready to fire. He estimates the lapse of time approximately in seconds since the last plotting by the range recorder up to include the time the piece will be in battery ready to fire. He announces to the gun commander the range corresponding to that time, taking it from the time-range curve, and sets the range scale for that range. The gun commander verifies the foregoing estimate and range setting, and if right will call *SET.**

### TO RETRACT THE GUN

To bring the gun from the firing to the loading position the gun commander commands *FROM BATTERY, HEAVE; HALT, CAST OFF.* At the first command Nos. 7 and 8 go to the retraction cranks. No. 7 releases the retaining pawl and turns the speed crank to permit the pulling out of the ropes. Nos. 9 and 10 mount on the gun levers and place the ends of the ropes on the hooks, receiving them from Nos. 3 (22) and 4, who mount on the chassis to assist. Nos. 1 and 2 pull out the ropes and pass the ends to Nos. 3 (22) and 4; No. 7 takes in the slack. Nos. 7, 8, 9, and 10 take positions at the retraction cranks, and at the second command turn them. Nos. 3, 4, 5, and 6 relieve Nos. 7, 8, 9, and 10 when directed by the gun commander. Odd numbers work on the right side of the carriage, even numbers on the left. When the gun has reached the loading position the command *HALT* is given. At the command *CAST OFF* No. 7 lets out enough slack to enable Nos. 1 and 2 to take the rope ends off the hooks. In retracting the gun by electric power the range setter operates the controller. At the first command he sets the maneuver lever for retracting and lets out slack to permit the cables to be pulled out. At the second command he operates the retracting motor, taking care that the gun levers do not strike the recoil buffers. At the third command he stops the motor, lets out enough slack for the removal of the ends of the ropes, sets the index to off *and throws the idler out of gear for retraction.* To prevent injury to the ropes by reverse winding in letting out slack, the chief of breech detail takes a position where he can see one of the drums and stops the unwinding before the last turn of the rope is off the drum. To prevent injury to the ropes by winding across the grooves in taking up slack, No. 1 watches the right drum and No. 2 the left until the ropes are taut; if either

* Par. 823½ C. A. D. R.

rope fails to wind in the proper groove the man on that side calls *HALT;* whereupon the winding is stopped and the rope adjusted, by No. 9 if on the right drum, by No. 10 if on the left. In retracting, the ropes should be under equal tension. Slight adjustments may be made by twisting one of the ropes, but appreciable difference in lengths must be adjusted at the drums.

### Ammunition Service

The number of men required for the ammunition service depends upon the type installation provided at the battery for this service. Nearly all major caliber gun batteries are equipped with electric projectile hoists, and many with powder hoists. For a two-gun battery equipped with electric projectile hoist, but no powder hoists, the requirement of men at each emplacement will be as follows:

#### FOR A 12-INCH BATTERY

The *Hoist Operator* (n.c.o. or private) operates the controller of the hoist, supervises the placing of projectiles on the receiving table of the hoist, repeats orders as to kind of projectile to be sent up, and is chief of projectile detail.

The *Projectile Detail,* 4 privates, numbered 1 to 4, work in pairs and transfer projectiles from the shot and shell rooms to the receiving table of the hoist.

In transferring projectiles Nos. 1 and 2 operate a trolley and differential pulley. No. 2 places the shot tongs over the gravity band of a projectile of the kind ordered, locks them, and steadies them, while No. 1 hoists, until there is sufficient weight on the tongs to prevent their slipping. No. 2 then assists No. 1 in hoisting. They stop hoisting when the projectile reaches the height of the receiving table, and run the trolley to the ammunition hoist, No. 1 pulling on the chains and No. 2 *pushing on the tongs.* No. 1 lowers the projectile upon the receiving table and No. 2 removes the tongs. They return the trolley for another projectile. In hoisting and lowering projectiles the men should keep the chain on which they pull in the plane of the sheave through which it passes. Nos. 3 and 4 operate other trolleys and pulleys. No. 3 performs the duties prescribed for No. 1, and No. 4 the duties prescribed for No. 2.

*Powder Detail,* 10 privates numbered from 5 to 14.

Two privates, Nos. 5 and 6, uncase cartridges and put empty cases aside. Eight privates, Nos. 7, 8, 9, and 10 and Nos. 11, 12, 13 and 14, work in relays of four men each, each man carrying a powder section from the magazine to the loading platform, where he places it on the powder serving tray. The powder detail should be in charge of a noncommissioned

officer. Total, 16 men; for the battery, 32 men and a chief of ammunition service (n. c. o.).

The powder charge for the 12-inch gun is made in four sections. For the 1888 and 1895 model gun each section weighs about 69 lbs.; total 275 lbs. For the 1900 model gun each section weighs about 81 lbs.; total 325 lbs. Special instructions as to the care and operation of the projectile hoists are posted at each hoist.

If the emplacement is equipped with a powder hoist, the powder detail should consist of a noncommissioned officer and 8 privates, numbered from 5 to 12. The noncommissioned officer operates the controller of the hoist, supervises the placing of the powder sections on the hoist, and gives such orders for the service of the powder as may be necessary.

Two privates, Nos. 5 and 6, uncase cartridges and put the empty cases aside. Four privates, Nos. 7, 8, 9, and 10 place the powder sections on the hoist and assist in the uncasing. Two privates, Nos. 11 and 12, take station at the powder hoist on the loading platform, receive the powder sections and align them carefully on the powder serving trays. At a battery equipped with powder hoists the ammunition section would consist of twenty-eight men and a chief of ammunition service (n. c. o.).

### FOR A 10-INCH BATTERY

The same details and number of men are required as for a 12-inch battery, except that in the powder detail only six men are required, as the powder charge is made in two sections. If there is no powder hoist, four men working in relays of two men each transfer the powder charge from the magazine to the powder serving trays on the loading platform. If there is a powder hoist, one man operates the controller of the hoist; two men uncase cartridges; two men transfer the powder sections to the hoist; and one man at the hoist on the loading platform receives the sections and aligns them on the powder serving trays.

For a two-gun battery, 24 men and a chief of ammunition service (n. c. o.) are required.

The *Chief of Ammunition Service* is in charge of the ammunition section and of the galleries and magazines of the battery.

He is responsible for the condition of the projectiles, trolleys, and hoists and for the police of the galleries and magazines. On the arrival of his section at the emplacement he commands *DETAILS, POSTS*. When the details are posted he makes an inspection of the trolleys, hoists, maga-

zines, and galleries and reports to the emplacement officer, "Sir, ammunition service, No.———in order," or reports defects he is unable to remedy without delay. During drill or action he supervises the service of ammunition.

### The Emplacement Officer

The emplacement officer is in charge of one or more emplacements. He is responsible to the battery commander:

(1) For the condition of the emplacement matériel.

(2) For the efficiency of its service.

Before drill, practice, or action he makes a careful inspection of the matériel under his charge. Having completed his inspection and having received the reports of the gun commanders and the chief of ammunition service, he reports to the battery commander, "Sir, No. ———, (or Battery) in order," or reports any defects he is unable to remedy without delay. During drill he should observe the work of the range recorders with a view of detecting any errors in plotting the ranges. He should watch the gun crews in loading the pieces. He should point out mistakes and should endeavor in every way to develop team work.

### To Dismiss The Battery

At the conclusion of drill, the battery commander commands *DISMISSED.* The emplacement officer repeats this command. The gun commander commands *SECURE PIECE, FORM SECTION*—The gun commander sees:

(1) That the breech and muzzle covers are replaced.

(2) That the exposed surfaces of the gun and carriage are properly coated with oil.

(3) That the drip pans are replaced.

(4) That the hook switch of the gun telephone is down and the telephone properly secured.

(5) That the trucks are replaced and the equipment and implements stored.

He then forms his section on the battery parade.

At the command *DISMISSED*, the chief of ammunition service commands *SECURE MAGAZINES, FORM SECTION.* He sees that all his apparatus is in order and that doors of magazines are shut and shell rooms locked, and forms his section and moves it to its proper place in the company line.

The emplacement officer makes a general inspection of

the battery, superintends the formation of the gun and ammunition sections and reports to the battery commander. The company, being reformed on the battery parade, is marched by an officer to the company parade and dismissed.

## NOTES AND SUGGESTIONS ON THE DRILL

With the Stockett breech mechanism there is danger of the short lanyard's getting fouled in the compound gear. A convenient arrangement for avoiding this is to fasten a piece of wire around the piece in rear of the elevating band with a hook in which the short lanyard may be hooked during loading.

The breech detail should be trained to open the breech promptly. The operation should begin as soon as the piece recoils within reach, and should be nearly completed by the time the piece settles.

The rammer and truck details should be trained in their duties with the gun at different notches, so as to secure uniformity in seating projectiles and rapidity in adjusting shot trucks under all conditions. Prior to practice or action, shot trucks should be adjusted to the highest point to which it is anticipated the gun will recoil, as the adjustment is made downward more easily and rapidly than upward

To prevent the dummy projectile from sticking, slush around the rotating band of the projectile with kerosene oil at the beginning of drill.

The above service of the piece can be made applicable to the 8-inch gun on a disappearing carriage by omitting all references to the chief of the breech detail, whose duties are performed by No. 1 of the breech detail; by placing only two men at the powder serving tray, and numbering them 16 and 17; and in the text omitting the numbers in parentheses which apply only to the 12-inch gun.

# NOTES ON INTERIOR BALLISTICS

By Colonel JAMES M. INGALLS, United States Army (Retired)

## III.

### Ratio of the Specific Heats of the Gases of Combustion of a Charge of Cordite

The formulas for velocity and pressure given in Chapter IV of my *Interior Ballistics* were deduced on the supposition that the ratio of the specific heats of the gases of combustion is 1⅓, as determined by the experiments of Noble and Abel with charges of gun powder exploded in a closed vessel. As has been shown in a previous note,* the formulas so deduced give velocities at various travels in the bore of a 6-inch gun, loaded with 20 lbs. of 0.3 inch cordite and a 100 lb. projectile, agreeing quite well with those measured by Sir Andrew Noble. It is proposed in this note to examine what changes in these computed velocities would result by varying this ratio within certain limits, and thus to ascertain whether or not some ratio differing from 1⅓ would give velocities more nearly in accordance with experiment. To accomplish this it will be necessary to generalize the formulas for velocity by introducing a symbol ($n$) depending upon this ratio in place of the number 1⅓. If we take $n$ so as to satisfy the equation

$$\frac{C_p}{C_v} = 1 + \frac{1}{n}$$

the resulting formulas will be reduced to their simplest form. The formulas into which $n$ enters, numbered as in Chapter IV for easy reference, are the following:

$$\sec\varphi = (1+x)^{\frac{1}{2n}} \tag{36}$$

$$X_0 = 2n\int \sec^n \varphi \, d\varphi \tag{37}$$

$$X_2 = \sin^2\varphi \tag{24}$$

$$v^2 = \frac{288ngfy}{w} X_2 \tag{8}$$

* Journal U. S. Artillery, May-June, 1913, page 293.

$$\overline{X}_0 = [1.20138]\frac{l_0 d^2}{v_c}\left(\frac{n}{aw\bar{\omega}}\right)^{\frac{1}{2}} = \frac{\lambda}{N} \tag{69}$$

$$V_1^2 = [3.96671]\frac{n f \bar{\omega}}{w} = \frac{\lambda M}{\alpha N} = \frac{V^2}{X_2} \tag{58}$$

For cordite $\alpha = 2$ and $\lambda = \frac{1}{2}$; and as the applications of the formulas in this note will be confined to the data pertaining to the English 6-inch gun fired with a charge of 20 lbs. of 0.3 inch cordite and a 100 lb. projectile, the above equations may be reduced, for the purposes of this note, to the following simpler forms:

$$v^2 = [1.96671]\, n\, f\, y\, X_2 \tag{a}$$

$$X_0 = \frac{[0.14861]\, n^{\frac{1}{2}}}{v_c} = \frac{1}{2N} \tag{b}$$

$$V_1^2 = [3.26774]\, nf = \frac{M}{4N} = \frac{V^2}{X_2} \tag{c}$$

Also the following, easily derived from these:

$$M = [3.42016]\, f v_c n^{\frac{1}{2}} \tag{d}$$

$$N = \frac{[9.55036-10]\, v_c}{n^{\frac{1}{2}}} \tag{e}$$

$$y = \frac{[8.03329-10]\, v^2}{nfX_2} = \frac{20}{V_1^2}\cdot\frac{v^2}{X_2} \tag{f}$$

The following table gives the expressions for $\sec\varphi$ and $X_0$ for the different values of $n$ considered in this note, namely, 2, 3, 4, and 6. They are deduced from (36) and (37):

| $n$ | $\sec\varphi$ | $X_0$ |
|---|---|---|
| 2 | $(1+x)^{\frac{1}{4}}$ | $4\tan\varphi$ |
| 3 | $(1+x)^{\frac{1}{6}}$ | $3\tan\varphi\sec\varphi + 3\log(\tan\varphi+\sec\varphi)$ |
| 4 | $(1+x)^{\frac{1}{8}}$ | $8\tan\varphi\,(1+\frac{1}{3}\tan^2\varphi)$ |
| 6 | $(1+x)^{\frac{1}{12}}$ | $12\tan\varphi\,(1+\frac{2}{3}\tan^2\varphi+\frac{1}{5}\tan^4\varphi)$ |

Table V gives the logarithms of $X_0$ and $X_2$ corresponding to the values of $u$ and $x$ given in the first two columns, for $n = 2$, 3, 4, and 6. It will be noted that since

$$X_1 = X_0\, X_2 \tag{18}$$

its logarithm is the sum of log $X_0$ and log $X_2$, and, thus being easily determined, has not been tabulated.

For cordite the velocity of the projectile for any travel in the bore is given by the equation

$$v^2 = MX_1 \ (1 - NX_0)$$

where $X_0$ and $X_1$ are functions of the travel, while $M$ and $N$ depend upon the gun, firing, and powder constants already given, and an assumed value for $n$. For the particular firing under consideration in this note, equations (d) and (e) show how the parameters $M$ and $N$ may be computed for any value of $n$ when $f$ and $v_c$ are known or assumed. They may also be found when either $f$, or $v_c$, and any interior velocity and corresponding travel of the projectile are known. And, lastly, when any two located interior velocities are known. Thus we may have four cases, which, as they are of some interest, will be considered separately

### CASE 1. $f$ AND $v_c$ GIVEN

In this case the values of $M$ and $N$ can be found by equations (d) and (e). For any travel ($u$) of the projectile in the bore, $x$ may be computed by the equation

$$x = \frac{u}{z_0}$$

and then $X_0$ and $X_1$ can be taken from a table of these functions, with $x$ as the argument. If no table is available, $X_0$ may be computed for the values of $n$ here considered by means of the formulas given in the table on page 276. Then $X_2$ and $X_1$ by (24) and (18).

To determine the travel of the projectile when the powder is all consumed, we compute $X_0$ by (b) and take the corresponding value of $\bar{x}$ from the table of the $X$ functions. The travel of the projectile is then computed by the equation

$$\bar{u} = \bar{x}\, z_0 = 3.0332\ \bar{x}$$

for the gun and charge under consideration.

If there be no table of the $X$ functions, we must equate the computed value of $\bar{X}_0$ to the proper expression in terms of tan $\varphi$, found in the table on page 276 for the particular value of $n$ under consideration. Having found the auxiliary angle $\varphi$ by solving the resulting equation we have frcm (36)

$$\bar{x} = \sec^{2n}\varphi - 1$$

If $n = 2$, we have

$$\tan \varphi = \frac{\bar{X}_0}{4}$$

by means of which $\varphi$ can easily be found, and then $\bar{x}$ and $\bar{u}$.

$$\overline{X}_0 = [1.20138]\frac{l_0 d^2}{v_0} ($$

$$V_1^2 = [3.96671]^n$$

For cordite $\alpha = 2$ and $\lambda$
the formulas in this note wil
to the English 6-inch gun
inch cordite and a 100 lb.
be reduced, for the pur
simpler forms:

$$v^2$$

$$X_0 = [0$$

$$V_1^2 =$$

Also the followin

The fo
for the di
2, 3, 4, a

| $n$ |
|---|
| 2 |

For condi[illegible] hich their values may be checked. Thus the bore is g[illegible] ent that $\frac{X_0}{n^{\frac{1}{2}}}$, $\frac{V_1^2}{n}$, and $X_0 N$ are constant for

where X [illegible] so in Table I, $\frac{v^2}{n\,y\,X_2}$ is constant. That is, depend [illegible] giving motion of translation to the projectile given, [illegible] $n$, $y$, and $X_2$.
under
how

Table I

of [illegible] velocities, and corresponding pounds of powder f[illegible] inch gun fired with a charge of 20 lbs. of 0.3 inch [illegible] 00 lb. projectile, for $n=2$, 3, 4, and 6 respectively. [illegible] ns are: $v_c = 0.30874$ inches per second and $f$ [illegible] per in.[2] for each value of $n$.

| | $n=2$ | | $n=3$ | | $n=4$ | | $n=6$ | |
|---|---|---|---|---|---|---|---|---|
| | [illegible]ocity | Powder burned | Velocity | Powder burned | Velocity | Powder burned | Velocity | Powder burned |
| | f.s. | lbs. | f.s. | lbs. | f.s. | lbs. | f.s. | lbs. |
| | 128.58 | 2.738 | 128.75 | 2.739 | 128.83 | 2.740 | 128.91 | 2.740 |
| | 842 | 9.402 | 856 | 9.444 | 863 | 9.464 | 870 | 9.485 |
| | 1077 | 11.100 | 1102 | 11.167 | 1115 | 11.201 | 1129 | 11.235 |
| | 1494 | 13.915 | 1551 | 14.047 | 1581 | 14.110 | 1612 | 14.176 |
| | 1923 | 16.650 | 2032 | 16.853 | 2090 | 16.960 | 2151 | 17.062 |
| | 2154 | 18.038 | 2301 | 18.281 | 2380 | 18.389 | 2463 | 18.500 |
| | 2317 | 18.948 | 2495 | 19.177 | 2592 | 19.284 | 2695 | 19.383 |
| 94 | 2521 | 19.857 | 2741 | 19.963 | 2863 | 19.990 | 2993 | 20.000 |
| 320 | 2540 | 19.912 | 2764 | 19.990 | 2888 | 20.000 | 3022 | ——— |
| 300 | 2559 | 19.958 | 2787 | 20.000 | 2915 | ——— | 3053 | ——— |
| .1 | 2582 | 19.993 | 2816 | ——— | 2948 | ——— | 3092 | ——— |
| 6.277 | 2597 | 20.000 | 2836 | ——— | 2972 | ——— | 3120 | ——— |
| 14 | 2640 | ——— | 2897 | ——— | 3044 | ——— | 3206 | ——— |
| 16.6 | 2652 | ——— | 2914 | ——— | 3065 | ——— | 3230 | ——— |
| Infinite | 3056 | ——— | 3743 | ——— | 4322 | ——— | 5293 | ——— |

CASE 2. $v_c$ AND $v$ GIVEN

For this case we will take, as before, $v_c = 0.30874$ and for the given velocity the measured muzzle velocity, namely, 2914 f.s. $\overline{X}_0$ and $N$ depending as they do only on $v_c$ and the gun, powder, and firing constants, have the same values as in Case I for the different values of $n$. Since the powder was all burned in the gun, $V_1$ is given by the equation

$$V_1^2 = \frac{V_m^2}{X_{2m}} = \frac{[6.92898]}{X_{2m}} \tag{c}$$

Also from (c), (d) and (f)

$$y\,f = \frac{[6.73226-10]\ V_1^3}{n}$$

$$M = \frac{[9.64201-10]\ V_1^3}{n^{\frac{1}{2}}}$$

$$y = \frac{20v^2}{V_1^2 X_2}$$

From these formulas Table II′, was computed. (See p. 281 for Table II′ and its derivative Table II.)

### CASE 3. $f$ AND $v$ GIVEN

For a numerical example illustrating this case, take $f$ = 2520.9, as in Case I, and $v = 2301$ f.s., which was the measured velocity when the projectile had traveled 12 ft. It is evident from (58) that $V_1$ for the different values of $n$ considered will have the same values as in Case I. Also, the parameter $N$ may be computed by equation (35), p. 114, *Interior Ballistics*, which for the data of this example, may be written

$$N = \frac{1}{2X_0}\left\{1-\left(1-\frac{v^2}{X_2 V_1^2}\right)^{\frac{1}{2}}\right\}$$

$v$, $X_0$, and $X_2$ referring to the same point of travel, namely, $u$ = 12 ft.

The other constants are determined by the equations (deduced from (b), (c), (d), and (g)),

$$M = 4N V_1^2$$

$$\overline{X}_0 = \frac{1}{2N}$$

$$v_c = [0.44964]\ Nn^{\frac{1}{2}} = [3.17828-10]\ \frac{M}{n^{\frac{1}{2}}}$$

$$V_1^2 = [6.66930]n$$

$$y = [4.63173-10]\ \frac{v^2}{nX_2}$$

By means of these formulas the following table was computed. They do not apply to $n$ = 2, since it is impossible for the gases with this value of $n$ and for $f$ = 2520.9 to generate a velocity of 2301 f.s. in a travel of 12 feet, no matter what the velocity of combustion may be.

Table II′

| | $n=2$ | $n=3$ | $n=4$ | $n=6$ |
|---|---|---|---|---|
| $\log V_1^2$ | 7.05230 | 7.14642 | 7.22759 | 7.35799 |
| $\log \bar{X}_0$ | 0.80954 | 0.89759 | 0.96005 | 1.04810 |
| $\bar{x}$ | 11.960 | 10.319 | 9.666 | 9.097 |
| $\bar{u}$ | 36.277 | 31.300 | 29.320 | 27.594 |
| $f$ | 3044.6 | 2520.9 | 2279.2 | 2051.6 |
| $\log M$ | 6.54380 | 6.54986 | 6.56865 | 6.61090 |
| $\log N$ | 8.88942−10 | 8.80138−10 | 8.73891−10 | 8.65086−10 |
| $\log\frac{20}{V_1^2}$ | 4.24873−10 | 4.15461−10 | 4.07345−10 | 3.94305−10 |

From this table and Table V the numbers contained in Table II were computed. In this case $V_1^2$ and $v^2$ vary with the force of the powder ($f$), in addition to what was mentioned in Case 1.

Table II

Computed velocities and corresponding pounds of powder burned, in a 6-inch gun fired with a charge of 20 lbs. of 0.3 inch cordite and a 100 lb. projectile, for $n$ = 2, 3, 4, and 6 respectively. The conditions are: $v_e$ = 0.30874 and $v$ = 2914 f.s. for each value of $n$.

| | $f=3044.6$ | | $f=2520.9$ | | $f=2279.2$ | | $f=2051.6$ | |
|---|---|---|---|---|---|---|---|---|
| | $n=2$ | | $n=3$ | | $n=4$ | | $n=6$ | |
| $u$ | $v$ | $y$ | $v$ | $y$ | $v$ | $y$ | $v$ | $y$ |
| ft. | f.s. | lbs. | f.s. | lbs. | f.s. | lbs. | f.s. | lbs. |
| 0.08 | 141.31 | 2.738 | 128.75 | 2.739 | 122.50 | 2.740 | 116.29 | 2.740 |
| 1.28 | 925 | 9.402 | 856 | 9.444 | 820 | 9.464 | 785 | 9.484 |
| 2 | 1183 | 11.100 | 1102 | 11.167 | 1061 | 11.201 | 1018 | 11.235 |
| 4 | 1641 | 13.915 | 1551 | 14.047 | 1503 | 14.111 | 1454 | 14.176 |
| 8 | 2113 | 16.650 | 2032 | 16.853 | 1988 | 16.960 | 1941 | 17.062 |
| 12 | 2367 | 18.038 | 2301 | 18.281 | 2263 | 18.389 | 2222 | 18.500 |
| 16.6 | 2547 | 18.948 | 2495 | 19.177 | 2465 | 19.284 | 2431 | 19.383 |
| 27.594 | 2770 | 19.857 | 2741 | 19.963 | 2718 | 19.922 | 2700 | 20.000 |
| 29.320 | 2791 | 19.912 | 2764 | 19.990 | 2746 | 20.000 | 2726 | ——— |
| 31.300 | 2812 | 19.958 | 2787 | 20.000 | 2771 | ——— | 2754 | ——— |
| 34.1 | 2838 | 19.993 | 2816 | ——— | 2804 | ——— | 2790 | ——— |
| 36.277 | 2854 | 20.000 | 2836 | ——— | 2826 | ——— | 2815 | ——— |
| 44 | 2901 | ——— | 2897 | ——— | 2894 | ——— | 2892 | ——— |
| 46.6 | 2914 | ——— | 2914 | ——— | 2914 | ——— | 2914 | ——— |
| Infinite | 3359 | ——— | 3743 | ——— | 4110 | ——— | 4775 | ——— |

Table III′

| | $n=2$ | $n=3$ | $n=4$ | $n=6$ |
|---|---|---|---|---|
| $\log V_1^2$ | 6.97033 | 7.14642 | 7.27136 | 7.44745 |
| $\log \overline{X}_0$ | ——— | 0.89759 | 1.01909 | 1.16039 |
| $\overline{x}$ | ——— | 10.319 | 14.240 | 18.403 |
| $\overline{u}$ | ——— | 31.300 | 43.193 | 55.821 |
| $v_0$ | ——— | 0.30874 | 0.26950 | 0.23840 |
| $\log M$ | ——— | 6.54986 | 6.55330 | 6.58809 |
| $\log N$ | ——— | 8.80138−10 | 8.67988−10 | 8.53858−10 |
| $\log \frac{20}{V_1^2}$ | ——— | 4.15461−10 | 4.02967−10 | 3.85358—10 |

Table III was computed by means of these numbers and those in Table V.

Table III

Computed velocities and corresponding pounds of powder burned, in a 6-inch gun fired with a charge of 20 lbs. of cordite and a 100 lb. projectile for $n=3$, 4, and 6 respectively. The conditions are: $f=2520.9$ lbs. per in.$^2$ and the projectile's velocity at a travel of 12 ft. is 2301 f.s., for each value of $n$.

| Distance traveled | $n=3$ | | $n=4$ | | $n=6$ | |
|---|---|---|---|---|---|---|
| | $v_c=0.30874$ | | $v_c=0.26950$ | | $v_c=0.23840$ | |
| | Velocity | Powder burned | Velocity | Powder burned | Velocity | Powder burned |
| ft. | f.s. | lbs. | f.s. | lbs. | f.s. | lbs. |
| 0.08 | 128.75 | 2.739 | 120.64 | 2.403 | 113.75 | 2.134 |
| 1.28 | 856 | 9.444 | 814 | 8.428 | 778 | 7.590 |
| 2 | 1102 | 11.167 | 1055 | 10.029 | 1015 | 9.077 |
| 4 | 1551 | 14.047 | 1505 | 12.781 | 1464 | 11.692 |
| 8 | 2032 | 16.853 | 2007 | 15.631 | 1984 | 14.513 |
| 12 | 2301 | 18.281 | 2301 | 17.189 | 2301 | 16.140 |
| 16.6 | 2495 | 19.177 | 2525 | 18.291 | 2550 | 17.359 |
| 31.300 | 2787 | 20.000 | 2898 | 19.774 | 2997 | 19.273 |
| 34.1 | 2816 | ——— | 2939 | 19.877 | 3050 | 19.458 |
| 43.193 | 2891 | ——— | 3037 | 20.000 | 3185 | 19.842 |
| 44 | 2897 | ——— | 3044 | ——— | 3195 | 19.863 |
| 46.6 | 2914 | ——— | 3065 | ——— | 3224 | 19.920 |
| 55.821 | 2966 | ——— | 3127 | ——— | 3306 | 20.000 |
| Infinite | 3743 | ——— | 4322 | ——— | 5293 | ——— |

CASE 4. TWO MEASURED VELOCITIES GIVEN

It has been shown that when $n=3$ the measured and com-

puted velocities for $u=12$ ft. and also for $u=$ 46.6 ft., are practically the same,* namely, $v_{12}$ = 2301 f.s. and $v_{46.6}$ = 2914 f.s. We will determine values of $M$, $N$, $v_c$, and $f$ which will give these velocities for the same travels of projectile when $n$ has the values 2, 4, and 6. Preliminary calculations show that if $n=2$ the powder would not all be burned in the gun. For this value of $n$ the parameters $M$ and $N$ must be computed by (30) and (31), Chapter V, *Interior Ballistics*, with the following data taken from Table V with the arguments $u'$ = 12 and $u''$ = 46.6:

$\log X_0' = 0.64635.$ $\log X_0'' = 0.84387.$

$\log X_1' = 0.38736.$ $\log X_1'' = 0.72055.$

Also $v_1 = 2301$ and $v_2 = 2914$.

Performing the required calculations we find for $n=2$,

$$\log M = 6.49586$$

$$\log N = 8.84106 - 10$$

We also have

$$V_1^2 = \frac{M}{4N} \qquad \text{(b)}$$

$$f = \frac{[6.13020 - 10]\, M}{n\, N} \qquad \text{(c)}$$

$$\overline{X}_0 = \frac{1}{2N} \qquad \text{(a)}$$

$$v_c = [0.44965]\, n^{\frac{1}{2}} N \qquad \text{(d)}$$

The values of $M$ and $N$ for $n=3$, 4, and 6 must be computed by (34) and (35), Chapter V, making $v_1 = 2301$, $V_m = 2914$, and taking $\log X_0'$, $\log X_2'$ and $\log X_{2m}$ from Table V. Performing the necessary calculations we have the following results.

Table IV′

| | $n=2$ | $n=3$ | $n=4$ | $n=6$ |
|---|---|---|---|---|
| $\log V_1^2$ | 7.05274 | 7.14642 | 7.22759 | 7.35798 |
| $\log \overline{X}_0$ | 0.85791 | 0.89759 | 0.92419 | 0.95075 |
| $\overline{x}$ | 17.051 | 10.319 | 7.707 | 5.051 |
| $\overline{u}$ | 51.718 | 31.300 | 23.377 | 15.320 |
| $\log M$ | 6.49586 | 6.54986 | 6.60443 | 6.70826 |
| $\log N$ | 8.84106 − 10 | 8.80138 − 10 | 8.77478 − 10 | 8.74822 − 10 |
| $f$ | 3047.7 | 2520.9 | 2279.2 | 2051 6 |
| $v_c$ | 0.27620 | 0.30874 | 0.33531 | 0.38632 |
| $\log \frac{20}{V_1^2}$ | 4.24829 − 10 | 4.15461 − 10 | 4.07345 − 10 | 3.94305 − 10 |

* JOURNAL U. S. ARTILLERY, May-June, p. 293, Table C.

## Table IV

Computed velocities and corresponding pounds of powder burned, in a 6-inch gun fired with a charge of 20 lbs. of 0.3 inch cordite and a 100 lb. projectile, when $n=2$, 3, 4, and 6, respectively. The conditions are: $v_{12}=2301$ f.s. and $v_{46.6}=2914$ f.s. for each value of $n$.

| Travel of projectile | $n=2$ | | $n=3$ | | $n=4$ | | $n=6$ | | Velocity measured by Sir Andrew Noble |
|---|---|---|---|---|---|---|---|---|---|
| | $f=3017.7$ $v_c=0.27620$ | | $f=2520.9$ $v_c=0.30874$ | | $f=2279.2$ $v_c=0.33531$ | | $f=2051.6$ $v_c=0.38632$ | | |
| feet | $v$ f.s. | $y$ lbs. | $v$ f.s. | $y$ lbs. | $v$ f.s. | $y$ lbs. | $v$ f.s. | $y$ lbs. | |
| 0.08 | 1333.99 | 2.459 | 128.75 | 2.739 | 127.16 | 2.966 | 129.18 | 3.397 | 60 |
| 1.28 | 883 | 8.551 | 856 | 9.444 | 847 | 10.139 | 860 | 11.393 | 810 |
| 2 | 1132 | 10.139 | 1102 | 11.167 | 1096 | 11.954 | 1110 | 13.340 | 1090 |
| 4 | 1577 | 12.827 | 1551 | 14.047 | 1546 | 14.935 | 1564 | 16.405 | 1570 |
| 8 | 2044 | 15.553 | 2032 | 16.853 | 2032 | 17.725 | 2046 | 18.957 | 2041 |
| 12 | 2301 | 17.026 | 2301 | 18.281 | 2301 | 19.013 | 2301 | 19.833 | 2301 |
| 15.320 | 2444 | 17.827 | 2450 | 18.982 | 2417 | 19.575 | 2431 | 20.000 | 2415 |
| 16.6 | 2488 | 18.071 | 2495 | 19.177 | 2492 | 19.715 | 2470 | | 2495 |
| 23.377 | 2662 | 18.987 | 2670 | 19.809 | 2656 | 20.000 | 2628 | — | 2666 |
| 31.300 | 2786 | 19.569 | 2787 | 20.000 | 2771 | — | 2754 | — | 2787 |
| 34.1 | 2818 | 19.697 | 2816 | — | 2803 | — | 2790 | — | 2821 |
| 44 | 2899 | 19.952 | 2897 | — | 2894 | — | 2892 | — | 2897 |
| 46.6 | 2914 | 19.980 | 2914 | — | 2914 | — | 2914 | — | 2914 |
| 51.718 | 2938 | 20.000 | 2944 | — | 2949 | — | 2954 | — | — |
| Infinite | 3360 | — | 3743 | — | 4110 | — | 4775 | — | — |

# Table V

| $u$ | $x$ | $n=2$ | | $n=3$ | | $n=4$ | | $n=6$ | |
|---|---|---|---|---|---|---|---|---|---|
| | | $\log X_0$ | $\log X_2$ | $\log X_0$ | $\log X_2$ | $\log X_0$ | $\log X_2$ | $\log X_0$ | $\log X_2$ |
| 0.08 | 0.0264 | 9.66068 | 8.11159 | 9.74889 | 7.93645 | 9.81143 | 7.81196 | 9.89956 | 7.63635 |
| 1.28 | 0.4220 | 0.24425 | 9.20793 | 0.33453 | 9.04427 | 0.39812 | 8.92559 | 0.48728 | 8.75579 |
| 2 | 0.6594 | 0.33188 | 9.34967 | 0.42321 | 9.19126 | 0.48733 | 9.07526 | 0.57701 | 8.90817 |
| 4 | 1.3187 | 0.46120 | 9.53566 | 0.55497 | 9.48824 | 0.62031 | 9.27789 | 0.71121 | 9.11658 |
| 8 | 2.6375 | 0.58092 | 9.67731 | 0.67835 | 9.54378 | 0.74549 | 9.44075 | 0.83819 | 9.28698 |
| 12 | 3.9562 | 0.64635 | 9.74101 | 0.74655 | 9.61645 | 0.81506 | 9.51824 | 0.90912 | 9.36950 |
| 15.320 | 5.0508 | 0.68421 | 9.77340 | 0.78654 | 9.65459 | 0.85576 | 9.55919 | 0.95075 | 9.41364 |
| 16.6 | 5.4728 | 0.69641 | 9.78315 | 0.79917 | 9.66596 | 0.86895 | 9.57178 | 0.96426 | 9.42730 |
| 23.337 | 7.7071 | 0.74716 | 9.82027 | 0.85298 | 9.71089 | 0.92419 | 9.62103 | 1.02105 | 9.48116 |
| 27.594 | 9.0974 | 0.77105 | 9.83588 | 0.87847 | 9.73024 | 0.95053 | 9.64248 | 1.04810 | 9.50489 |
| 29.320 | 9.6662 | 0.77968 | 9.84124 | 0.88769 | 9.73696 | 0.96006 | 9.64997 | 1.05793 | 9.51321 |
| 31.300 | 10.3192 | 0.78892 | 9.84681 | 0.89759 | 9.74399 | 0.97029 | 9.65783 | 1.06850 | 9.52199 |
| 34.1 | 11.2423 | 0.80093 | 9.85382 | 0.91049 | 9.75290 | 0.98363 | 9.66782 | 1.08226 | 9.53313 |
| 36.277 | 11.9598 | 0.80955 | 9.85867 | 0.91977 | 9.75912 | 0.99322 | 9.67482 | 1.09217 | 9.54098 |
| 43.193 | 14.2400 | 0.83355 | 9.87148 | 0.94568 | 9.77573 | 1.01901 | 9.69362 | 1.11995 | 9.56219 |
| 44 | 14.5061 | 0.83607 | 9.87277 | 0.94841 | 9.77741 | 1.02291 | 9.69554 | 1.12288 | 9.56436 |
| 46.6 | 15.3636 | 0.84387 | 9.87668 | 0.95686 | 9.78256 | 1.03168 | 9.70140 | 1.13197 | 9.57100 |
| 51.718 | 17.0507 | 0.85790 | 9.88345 | 0.97211 | 9.79154 | 1.04753 | 9.71168 | 1.14840 | 9.58272 |
| 55.821 | 18.4034 | 0.86811 | 9.88817 | 0.98322 | 9.79786 | 1.05908 | 9.71895 | 1.16039 | 9.59103 |

After the powder is all burned, we have in all cases and for all values of $n$,

$$V^2 = V_1^2 X_2$$

In Table IV′, $\frac{nNf}{M}$ and $\frac{v_c}{n^{\frac{1}{2}} N}$ are constant. Also the squares of the computed velocities in Table IV vary directly with $n$, $f$, $y$, and the function $X_2$.

### FORMULAS FOR PRESSURE IN TERMS OF $n$

If we make

$$X = \frac{1}{1 + \frac{1}{n} X_0 \cos^{n+1}\varphi \operatorname{cosec}\varphi}$$

we shall have,

$$X_3 = \frac{\sin\varphi \cos^{n+1}\varphi}{X} \tag{42}$$

$$X_4 = X_0 (1 + X) \tag{43}$$

$$X_5 = X^2 (1 + 2X) \tag{44}$$

After the powder is all burned we have,

$$P' = \frac{w\ V_1^2}{2\ n\ g\ \omega\ Z_0} \tag{30}$$

and

$$P = \frac{P'}{(1+x)^{\frac{n+1}{n}}} \tag{31}$$

# AIDS TO THE STUDY OF THE SIEGE OF PORT ARTHUR

By 1st Lieut. WALTER J. BUTTGENBACH, Coast Artillery Corps

Because of the voluminous literature called forth by the Russo-Japanese war, and because of the importance of suitable maps in the study of military operations, the writer has thought that he might render a service to the military student by bringing together in a short résumé mention of some of the principal publications referring to the siege of Port Arthur and an index to the maps that he has found most useful.

It has, of course, not been attempted to mention all publications concerning the siege of Port Arthur, but simply to mention a few of the most important, in the belief that they will point the way to others for all who are sufficiently interested in the subject to make the beginning here suggested.

The main sources of information are: the official accounts of the active combatants as far as published; the accounts of individual participants; the histories prepared by the general staffs of neutral countries, notably that prepared by the German General Staff; the accounts of such newspaper correspondents as really saw anything, of which, however, there were very few; and, lastly, the many articles that appeared in the periodicals of the world, of which those in the English papers, such as the *London Illustrated News* and the *Graphic*, were particularly rich in pictures. In making use of the last named material care must be taken to check with later publications, so that statements may be confirmed.

Of the first mentioned source we have the Russian Official Account, published both in French and in German. The French translation, now being published in Paris, is promised as a complete translation; while the German translation which has already come out in ten volumes, is abbreviated, the omissions being indicated. Of the ten German volumes, Volume 5, Parts I and II, comprising some 900 pages, treats of Port Arthur; but in the French translation the accounts of Port Arthur have not yet appeared.

Of the publication of the Japanese account a beginning has just been made in Japan, and it is not yet known whether it will be translated or not. For an extended review of its scope and probable value see the *Army Review*, October, 1912, pages 585-595.

Of histories prepared by the general staffs of neutral countries, we have that of the German General Staff, and that of the Austrian General Staff published in German by L. W. Seidel, of Vienna. But of neither of these has the volume referring to Port Arthur so far been published in English. Of the Austrian history, Part III, which refers to Port Arthur, has an excellent collection of maps, etc. (See BB in Symbols of References.)

Of publications by the English War Office, there are the *Reports of English Officers Attached to the Russian and Japanese Forces* which are very complete and especially rich in maps and drawings. The maps and drawings are separate from the text. In all, there are some three volumes of text and over one hundred plates. The parts referring to Port Arthur are scattered throughout the entire work. Then there is also the English Official Account, of which Part III treats of Port Arthur, giving a short history of the entire siege.

Of books written by participants there are but few in English, the most important being a translation of Tretjakow's *My Reminiscences of Nanshan and Port Arthur*, which gives an excellent account of the war as it appeared from day to day to one in it. Nojine's book, *The Truth about Port Arthur*, is in the main correct, but is so very prejudiced, having been written, apparently, to discredit General Stoessel and to promote the interests of General Smirnoff, that it should be read with caution, its bias being taken into account.

On the Japanese side we have Ashmead-Bartlett's *Port Arthur*, very interesting; Barry's *A Monster Heroism*, too journalistic and painted in too lurid a color; and *Human Bullets*, written by a Japanese officer. In the *Outlook*, there appeared during the war Keenan's *Port Arthur*, a short and very interesting account which was never published in book form. Other accounts whose authors accompained the Japanese Third Army are: *The Siege and Fall of Port Arthur*, by W. Richmond Smith; *The Siege of Port Arthur*, by David H. James; and *The Great Siege: The Investment and Fall of Port Arthur*, by B. W. Norregaard.

Among accounts that appeared originally in periodicals

mention should be made of the two volumes published in English by the *Kobe Chronicle.* They comprised a diary of the war as published in Japan, and were embellished by a set of fine photographs taken during the war.

Coming to our own publications, we have Major Kuhn's report, which is most valuable, being supplemented by many excellent plates and maps. It is a work that must be referred to constantly in any serious study of the siege. Then there is the pamphlet by Von Schwartz, *Influence of the Experience of the Siege of Port Arthur on the Construction of Modern Fortresses.* Both are publications of the War Department.

There are, besides, many detailed studies of certain phases of the siege published in various languages, especially in German, French, Russian, and Italian. These may be found from the lists given in *Publications of Recent Military Interest* and its present successor, the *Army Review,* published by the English General Staff. Also see the *Inedx to Current Military Literature* published by the JOURNAL OF THE UNITED STATES ARTILLERY at Fort Monroe. For German articles see Liman's *Almanach der Militar Literatur,* and *Von Löbel's Annual.*

The index to maps which follows comprises three lists of maps and a key to the symbols employed for reference.

The first list of maps, "General," is arranged chronologically, as the maps would be needed in a study of the Siege of Port Arthur. The second, "Detail," is arranged in sequence about the perimeter of the works. The third is a list of miscellaneous maps.

The maps selected for indexing do not necessarily include all maps pertaining to the publications that have been referred to, but only such as have been considered essential to the study of the siege.

The key to the symbols employed for reference follows the lists of maps.

### GENERAL MAPS

| | |
|---|---|
| General map—Seat of War; scale 1:5,000,000 | Map 1 AA |
| Strategical map, Campaign in Manchuria, Situation June 6th-8th, 1904; scale 1:750,000 | Strat. Map 2 CC v. 4 |
| Map of Kuantung Peninsula; scale 1:200,000 | Map 2 AA |
| Map of Kuantung Peninsula | Map 2 EE |

### Detail Maps

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| Water Works Redoubt; scale 1 inch = 60 feet | Plate 6 CC v. 3 |
| Works opposite Water Works Redoubt | Page 219 Part 2 AA |
| Port Arthur—Works South of Shui-Shiah-ying (Idol Redoubt Temple); scale 1:5280 | Map 75 DD |
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| Itzushan Fort (Fort No. 4) | Plate 26 GG |
| Taantzushan Fort (Fortification No. 4) | Plate 23 GG |
| Intermediate Work No. 4, with profiles Nos. 1 and 2 | Plate 15 AA |
| View of Takuschan as seen from the line of forts | Plate AA |
| Attack against Takuschan and Hsiaoku-schan, Aug. 7-8, 1904; scale 1:36,000 | Map 70 DD |
| Port Arthur—203 Meter Hill; scale 12 inches = 1 mile, V. I. 25 feet. | Map 5 CC v. 3 |
| Port Arthur—Operations 19-22 Sept., 1904; scale 1:21,120, V. I. 50 ft. (203 Meter Hill) | Map 74 DD |
| 203 Meter Hill—Approach, View of | Plate 20 CC v. 3 |
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| High Hill—Assault of Dec. 5th | Page 389 Part 2 AA |
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| Port Arthur—High Hill (203 Meter Hill) and its vicinity before the assaults at the end of November and the beginning of December; scale 1:30,000 | Plate 12 AA |
| 203 Meter Hill—Sketch of (From 174 M. Hill) | Plate 12 GG |
| Hsitaiyangkou Fort (Redoubt No. 5) | Plate 25 GG |
| Taiyankou—North Fort (Fort No. 5) | Plate 24 GG |
| Trenches in the plan of Fort No. 6 | Page 9 Part 2 AA |

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|---|---|
| South-East Redoubt (Takhe Redoubt) | Plate 13 GG |
| Golden Hill Mortar Battery | Plate 28 GG |
| Battery No. 16, with plans | Plate 15 AA |
| Views of Port Arthur | Supp. 10a and 10b BB |
| Port Arthur | Panorama 10 DD |
| Port Arthur—Details of plans of works, etc. (Separate cuts) | Plate 15 AA |

### Miscellaneous

| | |
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| Organization 3d Japanese army (Table) | Supp. 2 BB |
| Organization Russian Forces of the Kuantung (Table) | Supp. 3 BB |
| Port Arthur—Fortress of; map giving English names (See also Nojine's *The Truth about Port Arthur*) | FF |
| Comparative table of Names—Port Arthur | App. A CC v. 3 |
| Heavy armament of Port Arthur (to be placed over Map 111/3) | Plate 3 CC v. 3 |
| Armament tables of Maps 111/2-111/4-111/6 | App. I CC |
| Table giving data of guns in the works of Port Arthur | Supp. 4 BB |
| Cover for 4 field guns with plan | Plate 15 AA |
| Observation tower for a fort, with profile | Plate 15 AA |
| Observation tower on peak of Folsenrucken with profile | Plate 15 AA |
| Trenches with head cover, etc. | Plate 15 AA |
| Bombproofs, etc. | Plate 15 AA |
| Spherical mines | Page 225 Part 2 AA |
| Japanese and Russian loopholes, etc. | Plate 21 CC v. 3 |
| Japanese wooden mortars and grenades | Plate 22 CC v. 3 |
| Japanese siege trenches; scale 1 inch = 10 feet | Plate 19 CC v. 3 |
| Japanese platform for 11-inch howitzer | Plate 18 CC v. 3 |
| Japanese platform for 6-inch gun; scale 1 inch = 8 feet | Plate 17 CC v. 3 |
| Japanese battery at G (Map 111/2) for 4.7-inch guns; Open Caponiere No. 3; scale 1 inch = 40 yds., V.I. = 5 ft. | Plate 16 CC v. 3 |

## Symbols of References

AA Russian General Staff Account, as translated into German by Von Tettau, Vol. 5, parts 1 and 2. Published by Mittler and Son, Berlin.

(Typewritten translation, without maps, of above made by 1st Lieut. W. J. Buttgenbach, on file in War College Division, 1912.)

BB Einzelschriften uber den Russisch-Japanischen Krieg. 3 Band, 2 Auflage. Published by L. W. Seidel and Son, Vienna, Austria, 1909.

CC Official History of the Russo-Japanese War, Parts III and IV. Port Arthur. Prepared by Historical Section of Committee of Imperial Defenses. 1909.

DD The Russo-Japanese War: Reports from British Officers Attached to Russian and Japanese Forces in the Field. Published by English Government. 1908.

EE My Experiences at Nanshan and Port Arthur, by Lieut. General N. A. Tretjakow, as translated by Lieut. A. C. Alford, R. A., and published by H. Rees, London, 1911.

FF Influence of the Experience of the Siege of Port Arthur upon the Construction of Modern Fortresses, by Von Schwartz. Translation published by the War Department, U. S. A. 1908.

GG Reports of Military Observers Attached to the Armies in Manchuria during the Russo-Japanese War. Published by the War Department. 1907. Part 3. Major Kuhn, C. E.

# DEVICE FOR CHECKING FINAL AZIMUTHS USED IN MORTAR FIRE

By 2nd Lieutenant JOSEPH R. CYGON, Coast Artillery Corps

Realizing the importance of checking the final azimuth sent to the booths, it has occurred to me that, if I were provided with an additional deflection board and a reliable man to operate it, I should then be able to check the final azimuth with the same accuracy as the regular deflection board man determines it; and in so doing I should be making an absolute check, for both boards being operated under like conditions and with the same data, the same azimuth should be obtained.

All other devices designed for this purpose that I have seen used, have been a check only in that they made a comparison between previous angular differences and those to be expected, which, by no means, was ever an accurate check; for no definite result was obtained. They merely afforded the satisfaction incident to the fact that the pins or points used for marking the successive azimuths of the set-forward point fell at a uniform distance apart, but at no time did they give the exact azimuth that should be sent to the guns.

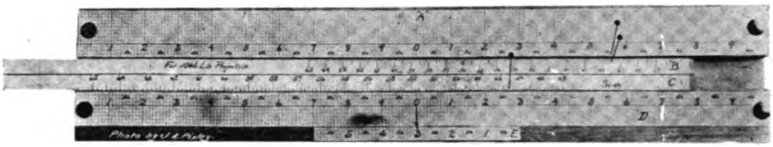
It was expected, in that method of checking, that by noting the sudden change in the relative positions of his pins or marks, one should be easily able to tell when a dangerous jump in azimuth occurred. But an experienced man will often get confused when a change of zone or loss of predictions occurs, and, having several things to attend to at about the same time, it is not at all improbable that he will fail to hear the change in zone or loss of prediction; so what is only an apparent error looks to him like a serious one. For these and similar reasons the operator begins to lose confidence in himself and the device he is using, with the result that he not infrequently observes what looks to him like an error but fails to report it, for fear that he is the one making the error.

It is my belief that, if the operator of such a device had some definite result to expect, he would never have occasion to doubt the results he obtains.

Not being provided with an additional deflection board, I have used for checking purposes, during the entire drill season of this year, what may be termed an "improvised deflection board," for from it I obtain the same results as from the adopted deflection board, and even with a greater degree of accuracy, as will be explained later. In addition, and without extra trouble, I am able to get the same information as has heretofore been obtained from other devices.

The device described herein is very simple to operate and very inexpensive to make, for it can be made in an hour or so from material at the post. It consists, in general, of a rectangular block of soft wood about 20 inches long, 4 inches wide, and 2 inches thick. Along the center is a longitudinal groove about 1 inch wide by ½ inch deep, in which a slide, of the same material and length as the block, is designed to move.

The illustration shows the board ready for use. The top scale "A" is made of square inch cross section paper pasted, or glued, flush with the edge of the groove and gradu-



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ated in degrees, beginning with zero at the center, to 10 at both ends with half-degree points marked. Scale "D" is made exactly like scale "A," but should be fastened with thumb tacks and not pasted. Under normal conditions, i.e., before any arbitrary deflection correction is made, the corresponding graduations on these two scales should be exactly opposite each other. Scale "E" is the arbitrary deflection correction scale with graduations as shown, beginning with zero on the right, to 6 on the left with 3 as normal, and is pasted flush with the lower edge of scale "D." It will be noted that the graduations on this scale ("E") read just opposite to those on the adopted deflection board, for the reason that, in order to set off an arbitrary correction, the azimuth scale "D" is moved, instead of a pointer.

The top and bottom surfaces of the "slide" are pasted over with plain white paper, one side graduated for use with the 1046 lb. projectile and the other for subcaliber practice. The graduations on the slide are in degrees and minutes of elevation.

Scale "B" is graduated at equal intervals on a scale of 1 inch = 2 degrees, beginning with the 45 degree graduation far enough to the right for the 65 degree graduation on scale "C" to fall on the slide. Scale "C" is also graduated in degrees and minutes of elevation, and in such a manner that the degree graduations on scale "C" will be at distances from the corresponding graduations on scale "B" equal to the drift at those elevations. The drift, being in degrees and hundredths, may be measured off directly from either scale "A" or "D" and applied to the proper elevation on scale "B" to obtain the corresponding elevation on scale "C." For example, the range table for the 1046 lb. projectile gives a drift of 2.63 degrees for an elevation of 45 degrees; from the 45 degree graduation on scale "B" lay off 2.63 degrees to the left to obtain the 45 degree graduation on scale "C." In like manner all other degree graduations on scale "C" are obtained. The opposite side of the slide may be graduated in a similar manner for use with the subcaliber or any other projectile.

The operator of this device should be a man equally as reliable as the regular deflection board man, and should be provided with a number of large headed pins to be used in the operation of the board. His position should be such that he is always near the battery commander or other person authorized to give "relay" in case an error occurs.

From his position he should be able to hear the elevation and uncorrected azimuth of the set-forward point, which would necessitate placing him near the plotting board; or, if he is to be near the battery commander, he should be connected by head-set to some one in the plotting room, preferably to No. 1, the man who reads the uncorrected azimuth of the set-forward point.

The operation of the board is as follows:

When the operator hears the elevation called out by the plotter, he sticks a large headed pin in the slide at the elevation on both "B" and "C" scales. Immediately afterwards he hears the uncorrected azimuth called out by No. 1 and sticks another pin near the lower edge of scale "A" at the azimuth, and then moves the slide so that the pin in scale "B" falls opposite the one in scale "A"; he now looks on scale "D" opposite the pin in scale "C" for the exact final azimuth that should be read out by the regular deflection board man.

It will be noted that only the last figure of any whole number of degrees appears on scales "A" and "D"; so that, in

comparing his results with what he hears No. 4 read out, he is, to a certain extent, dependent on the last figure of the whole degrees for his comparison.

In addition to checking the final azimuth, he also, by leaving the pins stuck in scale "A" for each successive uncorrected azimuth and noting whether or not these pins fall at uniform intervals, checks the uncorrected azimuths as read out by No. 1.

An example of its operation is as follows:

The plotter calls out, "Elevation, 47-30"; the operator sticks a pin at 47-30 on scale "B" and another at 47-30 on scale "C." No. 1 reads off an uncorrected azimuth, "235.60"; the operator sticks another pin in scale "A" to the right of figure 5 at 60 hundredths, and moves his slide so that the 47-30 pin in scale "B" falls opposite the 5.60 pin in scale "A," and then reads off 2.69 opposite the 47-30 pin in scale "C." The operator then expects to hear the regular deflection board man read off an azimuth that will have 2.69 degrees as its last three figures.

If it is desired to make an arbitrary correction at any time, scale "D" is moved so as to bring the normal opposite the proper setting.

It will be noted that the results obtained from this device permit of even a greater degree of accuracy than the adopted deflection board, for the reason that the elevation scale graduations are made on a considerably larger scale.

# GASOLINE: DENSITY AND EFFICIENCY

BY 1ST LIEUTENANT LE ROY BARTLETT, COAST ARTILLERY CORPS

The tremendous increase in number of automobile and other gasoline engines during the last few years, together with the demand for increased efficiency (i.e., miles per gallon, ease of starting, non-carbonizing, etc.), has stimulated the motor manufacturers and oil refiners to a more comprehensive and exhaustive study of the entire subject of gasoline. At present, the mass of conflicting advice which can be obtained on this subject is bewildering.

The *Encyclopedia Britannica* gives the following densities:

| | |
|---|---|
| Gasoline | .67 to .71 |
| Naphtha | .78 to .75 |
| Kerosene | .75 to .82 |

Yet there is now being manufactured from California crude oil a satisfactory gasoline whose density is .76, while a sample from Borneo crude shows .81.

The commercial scale used for measuring the density of fuel oils is the Baumé, and not specific gravity. The two are continually confused in articles on this subject. For instance, the booklet on one of the new 1914 six-cylinder machines states, "This machine runs best on gasoline of not less than 74 specific gravity." Baumé is evidently meant. Think of it. This machine will not run except on the most expensive gasoline. We shall now proceed to show that the most expensive is not necessarily the best.

In order to cover this subject properly it is necessary to begin with gravity. Specific gravity is the weight of any substance referred to water as unity. Fuel oils, being lighter than water, are all expressed by a decimal, as .76.

In the Baumé scale, water at 54°.5 F., containing 10 per cent by weight of common salt, is the zero of the scale; and pure water is 10 degrees. A liquid lighter than water has, then, a gravity greater than 10. Hence gasoline, gravity 66 degrees, is heavier than gasoline, gravity 76. This is the exact opposite of specific gravity. As the Baumé scale is

always used by the refiners, this scale will be referred to in the remainder of this article, unless otherwise stated.

A test of the number of British thermal units in the different grades (and heat units mean power) shows that as gravity decreases, the B.T.U.'s increase in almost direct ratio. But the lower grades are the cheapest. Therefore low grade gasoline means more power and cheaper power. If other considerations did not enter into the problem this discussion would end here.

We are informed by a recent bulletin of the refiners that after an exhaustive test the following gasolines are found to give the best results:

| | |
|---|---|
| Pennsylvania | 66 |
| Ohio | 62 |
| Kansas and Oklahoma | 58 |
| Texas and California | 56 |

Why this difference depending on the oil field? We are partially enlightened when we find that the crude oils from which these gasolines are refined differ in gravity by exactly the same amount.

Now, if low grade means cheap power and more power, why not use the lowest grade? The automobile operator who has run all summer on a low grade, only to go out the morning after the first frost and spend an hour cranking without results until advised by a friendly neighbor to fill the radiator with hot water, will tell you, "Use low grade in summer and high grade in winter." Why? The low grade will not vaporize in cold weather. Hence, we come to a discussion of the boiling point, which involves the entire subject of refining.

If we take crude oil and slowly heat it, we find that at each successive stage of temperature new vapors are given off, from normal butane at 1 degree C. to pentatriacontane at 331 degrees C. As a general classification, those given off between 60 and 160 degrees F. are called gasoline; from 160 to 250 degrees F., naphtha; 250 to 350, kerosene. The boiling point rises with the specific gravity. The "flash point" is slightly lower than this; i.e., the point at which vaporization commences. When the engine is cold, we must, therefore, use a high grade gasoline to start it. After it gets warm, the low grade is cheaper and better. The denser kerosenes will not, as a rule, operate in an ordinary gasoline engine; because, if the engine gets hot enough to vaporize them, mechanical difficulties interfere.

If, in order to get the above results, we mix in equal parts gasolines of 100 degrees F. and 160 degrees F. boiling point, we do not get a mixture of 130 degrees: we still have a mixture in which, until the engine gets hot, the low grade is simply burned, thereby corbonizing the cylinders and seriously interfering with the efficiency, because there are no connecting links between the two boiling points. Hence, the statement often made, that three parts of gasoline and one part of kerosene gives better results, is not correct. Likewise, gravity is not always a guide.

From the foregoing discussion we come to the definite conclusion, "Use the lowest grade gasoline which will start the motor." The manufacturers and inventors are now working on the problem of how to design an engine which will work satisfactorily on low grade gasoline. Some of the means of solution are improvements in the carburetors, using the exhaust to heat the mixture before intake, self starters, and better primers. The most important suggestion to this end recently made, is to have a small reservoir holding about one pint of high grade gasoline and connected with the primer. The engine is started on this, and the main tank of low grade gasoline is then switched on.

In the operation of our coast defense power plants the problem is somewhat different. To bring them into action without delay is the primary consideration, and economy is secondary. The two are not, however, irreconcilable. Few of our direct connected gasoline sets have an up-to-date carburetor. If, where it is practicable, post power were brought to the switch board, the generator could be used as a self starter. The gasoline at intake could be warmed by an electric rheostat.

In conclusion, we may remark that the exhaustion of the gasoline supply is a matter of considerable interest. The more general use of the low grades will extend this time limit very materially.

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# WAR COLOR FOR ARTILLERY HARBOR BOATS

By Brigadier-General CHARLES J. BAILEY, U. S. Army

An officer recently visiting the defenses of Puget Sound stated that he intended painting certain harbor boats the naval war color and, on being asked his reasons, replied that he desired to simulate war conditions at night drills, making it more difficult to pick up the boats in the searchlight beam.

Experience here has shown that this object will not be attained by painting the boats as proposed; and, as such experience is more extended in this command than in some others, the following is submitted for the benefit of those interested in the subject.

There are mounted in the three forts, Worden, Casey, and Flagler, more 60-inch searchlights than in any two other harbor entrances. These lights were located after extensive experiments by Major W. C. Davis, C. A. C., with portable 36-inch lights; and, after some three years trial, the opinion of those using the lights is that they are suitably placed for the defense of Admiralty Inlet.

At the weekly night drills all these lights are in use. The harbor boats approach from many directions, as the entrance is very wide, 7500 yards; and in no other locality, except perhaps at Corregidor, are the boats as free to take the various orders of approach that can be assumed by a hostile fleet. As a result, the three garrisons can practice with the lights under every contingency likely to arise; and, while the high sites of most of the batteries and stations are unusually favorable for searchlight work, the experience gained, at least in comparing visibility of targets of various colors, will be of value in places not so advantageously located and equipped.

Four boats are available at times for night drills:

The Mine Planter *Ringgold;* 145 feet; black hull, white upper works, yellow masts and stack.

The Harbor Boat *Mifflin;* 132 feet; white hull and upper works, yellow stack and masts.

The Harbor Boat *Springer;* 60 foot launch; white hull and upper works.

The Harbor Boat *Thomas;* 105 feet; *war color* on hull, upper works, stack, and masts.

The *Thomas* was painted this color about 1908 and has been present at nearly every night drill since, the other boats having come and gone as other duty permitted.

There has never been a night drill, at least since the writer joined this command in 1911, when it has not been *practically as easy* to pick up the *Thomas* as any of the other boats, and it is only when a white boat comes near the *Thomas* that any difference can be seen between them in the searchlight beam. The *Thomas* has never passed through the barrier beam undetected and has frequently been picked up and identified at a distance of 10,500-11,000 yards. She was discovered in the beam, one bright moonlight night, over 10,000 yards away and has often been reported by the observers at Fort Flagler as visible at a distance of 17,000 yards, when in the beams of the lights at Worden and Casey, 8000 yards nearer the boat. All this in war color.

These facts were told recently to a well informed naval officer and he stated in reply that the visibility of the war color at night was well known in the Navy, and that it had been selected for its invisibility by day rather than by night.

For night work alone black is believed the best color.

Unless some other reason makes a change necessary, no advantage will be gained, it is believed, in putting the war color on harbor boats. Some disadvantage, however, will result and experience here may again be of interest.

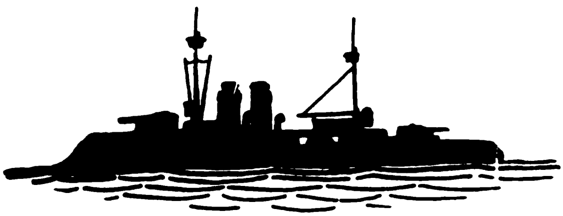
Existing orders are explicit as to care of boats, cleanliness, etc. No war colored boat ever presents a clean appearance, unless the paint is full of varnish, which defeats its object, invisibility; and even then the first impression is not that gained when the color is lighter. This is quite as true of a battleship as of a tugboat; but in the former the purpose for which it is created is so evident and so striking that the somber color adds to its warlike appearance. There is nothing warlike in the appearance of a harbor boat and it is believed no reason calls for a color that is disfiguring and unnecessary.

The crew of the *Thomas* put quite as much work on the police of the boat as other crews on theirs, yet she never looked clean. In putting on the war color it should cover every possible exposed part of the boat. Benches, rail, deck, small

boats, all require it; and no amount of cleaning takes away the dingy and dirty appearance of the outfit. This the crew of the *Thomas* realized; for, scrub as they might, there was never an adequate reward for their work in the resulting appearance of the boat.

She is now white and is as clean as any boat should be that does the work required of her. The crew, from the master down, have a pride in her and compare her with the others, in their own opinion, to her advantage.

War color, should hostilities threaten, can be applied to any harbor boat in a few hours. It is believed its application should be deferred until that time.



# COAST DEFENSE IN THE CIVIL WAR*

## FORT MACON, NORTH CAROLINA

By 1st Lieut. WALTER J. BUTTGENBACH, Coast Artillery Corps

### General Situation

After the fall of the works on Roanoke Island on February 8th, 1862, the Federal advance was continued. Elizabeth City, Edenton, and New Berne were taken, the battle of New Berne being fought March 14th, 1862.

This expedition, including the capture of Fort Macon, became known as the Burnside Expedition, and was in continuance of the general scheme of operations that commenced with the capture of Roanoke Island.

### Special Situation

After the fall of New Berne, the next objective, and last of the expedition, was the capture of Fort Macon, which occurred on the 26th of April, 1862.

### Opposing Forces

Fort Macon was situated on the extreme easterly end of Borden's Banks, also known as Bogue Island, a narrow sand island off the Carolina coasts, stretching to the westward a distance of some twenty-five miles and separated from the mainland by Bogue Sound. The sound is extremely shallow, permitting almost no navigation except by light draught vessels. From a point on the island about opposite Carolina City to the fort, a distance of some five miles, the surface of the island, a short distance back from the beach, is broken by irregular sand knolls varying in height and extent. Towards the sound these knolls decrease in size till they disappear in an extensive salt marsh, through which run numerous creeks.

* See note to "Coast Defense in the Civil War, Fort Sumter, S. C. (First Attack)," in Journal U. S. Artillery, March-April, 1912.

Fort Macon was an old style, strong, stone, casemated work said to mount 67 guns, garrisoned by some 500 Confederates and commanded by Colonel M. J. White. It controlled the channel from the open sea to Beaufort Harbor. It was about forty miles from New Berne.

The Federal force consisted of General Parke's brigade, together with a siege train consisting of 3 batteries, of which one had 3 rifled 30-pdr. Parrotts, another 4 8-inch mortars, and a third 4 10-inch mortars. There was also 1 12-pdr. Dahlgren rifled boat howitzer.

Smaller vessels of the Navy belonging to the blockading fleet also took part.

## Narrative of Events

General Parke, with his brigade, was given immediate charge of the operations against Fort Macon. On the 18th of March Havelock Station was occupied by one company of the 5th Rhode Island Battalion. On the 21st, Carolina City, a small settlement opposite Bogue Island, was taken; on the 22nd, two companies of the 4th Rhode Island took possession of Morehead City; on the night of the 25th, a detachment of the same regiment with a company of the 8th Connecticut occupied Beaufort; while on the night of the 23rd, Newport was garrisoned by the 5th Rhode Island. Thus all important positions around or in the vicinity of Fort Macon had fallen into possession of the Federal forces practically without a fight or the loss of a man.

General Parke, who had at this time (March 23rd) established his headquarters at Carolina City, demanded the surrender of the fort, which was refused.

It was then decided to besiege the works and, as soon as possible, to make a combined land and sea attack. The plan contemplated an attack similar to that against Port Royal and was one gotten up by Commander Lockwood which, on being referred to General Parke, was adopted by him.

On the 29th, a part of the 3rd Brigade were landed on Bogue Island, the Federal forces establishing their permanent camp on one of the crëeks on the island called Hoop Pole, about eight miles from the fort.

To this point were transported all troops, supplies, siege guns, etc., in scows or small boats, the work being carried on, as a rule, only at time of high tide, because of the intricacies

of the channel and the shallowness of the water. From March 29th to April 10th every available hour of the day and night was spent in transporting men, siege trains, and supplies.

During this time 8 companies of the 4th Rhode Island Regiment; 7 companies of the 8th Connecticut; the 5th Rhode Island Battalion; Company C, 1st U. S. Artillery; Company I, 3rd New York Artillery; and the siege train were brought over.

With troops, as already mentioned, occupying Beaufort (3 companies) and Morehead City (2 companies), the terminus of the railway, communication between those points and the fort was broken off, all boats were seized and all supplies cut off. Besides, there was a gunboat blockading Core Sound, and two small boats at Carolina City, thus cutting off all communications through Bogue Sound. From Beaufort communication was opened up with the blockading fleet, a signal officer of the Army being placed aboard the vessel of the Commanding Officer; and a landing was made on the Banks opposite Carolina City, thus completely investing the Confederate work.

The Confederates at this time seemed very active about and in the fort, all parties of Federal troops crossing from Morehead City to Beaufort or anywhere within range of the guns of the fort being fired on.

On April 11th a reconnaissance was made in force and contact gained with the Confederate pickets, which were driven in after a short skirmish. An advance was made to within a mile of the fort, when its guns opened up with shot and shell. Examination was made of the ground in front and sites were selected for Federal batteries from 1300 to 1700 yds. from the work. During this reconnaissance the gunboats engaged the fort, shelling the beach in front and rendering great assistance.

The terrane of the island, as already mentioned, was much cut up by sand hills, and was well adapted to facilitate the operations of the Federal forces. The ridges, or hills, intervened between the working parties and the fort to such an extent as to permit the construction of siege works to go on by day as well as by night without any serious inconvenience of fire.

On the ocean side, the blockading squadron consisted of the steamers *Daylight*, *State of Georgia*, and *Chippewa*, and the bark *Gemsbok*, all under command of Commander Lockwood.

On the 12th a permanent advance guard of five companies

was organized and work on the approaches was commenced. A small engagement took place this day and the Confederates (2 companies) were driven back. From this time on, the regular work on the approaches, trenches, batteries, and rifle pits was vigorously pushed forward by all available forces, only a desultory fire being kept up by the Confederates. Artillery fire was employed by the Confederates; but, having no mortars, they made use of six old 32-pdr. carronades, having an elevation of 40 degrees, for throwing shell behind the cover of the besieging force. Two 10-inch guns were also used for the same purpose. Little, however, was seen of the working parties; and, moreover, due to the scarcity of shell, continuous fire could not be kept up.

The road along the beach being in full view of the lookout on the fort, it became necessary to transport guns, mortars, and ammunition to the batteries and magazines under cover of night. The Confederates made two ineffectual attempts at night to dislodge the Federals from their advanced positions, but failed.

In selecting sites for the batteries, advantage was taken of the sand hills above mentioned. The depot at the landing was distant some four and a half miles along a sandy beach from the line of batteries. The batteries were established as follows:

The 10-inch mortar battery (Flagler's), consisting of 4 10-inch mortars, was near the marsh on the left side of the island, 1680 yds. from the fort and behind a natural sand hill high enough to protect the men from direct fire.

The 30-pdr. battery (Morris'), consisting of 3 30-pdr. rifled Parrott guns, was 200 yards in front of Flagler's battery and a little to the right of it, though, indeed, it was almost directly in front of it, on account of the narrowness of the strip of land available.

The 8-inch mortar battery (Prouty's), consisting of 4 8-inch mortars, was placed still 200 yards farther in advance and on the right, near the seaside.

Then there was Caswell's battery, 1 12-pdr. Dahlgren rifled boat howitzer.

On the morning of the 24th the two mortar batteries were ready to open fire, as was also the Parrott gun battery, with the exception of the opening of the embrasures, which was delayed until the moment of commencing fire had been arranged,

so that the Confederates might not discover the battery's position.

When the works were all completed and everything was ready for attack, Colonel White was again summoned to surrender and he again declined.

During the night of the 24th the embrasures of the Parrott gun battery were opened; and at 5:40 a.m. April 25th the first shot was fired upon the fort. Immediately all three of the batteries opened up and the fort responded to the fire.

Owing to the high wind and rough sea, it was impracticable to communicate to the blockading fleet that the land forces were to open fire at that time; but as soon as the commanding officer of the fleet, Captain Lockwood, discovered what was going on, he brought all his vessels into action, and for a time attracted the Confederate's attention to such an extent as greatly to aid the officers in charge of the batteries in correcting their ranges and in setting their fuzes.

The Navy steamers, *Daylight*, *State of Georgia*, and *Chippewa* came into action about 7:30 a.m., and were kept under way in regular order, line ahead, steaming in a circle, delivering their fire as they came within range at a mile and a quarter from the fort. The bark *Gemsbok* was anchored. The ships engaged for an hour and a quarter, at the end of which time the sea, made rough by a southwest wind, causing them to roll so rapidly and excessively as to render their guns almost unmanageable, they withdrew. The intention was to wait till afternoon, in the hope that wind and sea would subside sufficiently for them to engage the fort again; but the wind increased, so the fleet did not again get into action. However, the naval attack was most opportune, for it drew the fire of the enemy from an important land battery, thereby enabling it to repair damages.

The bombardment from the Federal batteries continued for some ten hours, and the fire was reported to have been not only vigorous but also accurate and effective. Shells dropped into the fort and exploded, making many breaches and sweeping the ramparts clean of gunners.

The fire was returned by twenty-one guns from the fort, there being included amongst them one 8-inch columbiad, and two 10-inch columbiads and six 32-pdrs. mounted as mortars. At first the fire of the Confederates was very rapid, shell and shrapnel being used chiefly, and the fort was so enveloped in smoke that it was difficult to tell whether the

Federal shells were falling within or beyond. At 9 a.m. the signal officer at Beaufort sent a message saying the mortars were "firing too far."* This error was immediately corrected, and shortly afterward the Confederate fire was somewhat slackened.

During the afternoon fire was continued, but slowly in order to reserve ammunition enough for night firing if necessary.

At about 5:00 p.m. a white flag was displayed on the ramparts of the fort, and, the firing ceasing on both sides, request was made for terms of surrender. In the Confederate reports it is stated that "at 6:30 p.m. finding that our loss had been very great, and from the fatigue of our men being unable to keep up the fire with but two guns, a proposition was made to General Parke for the surrender of Fort Macon." There was also discontent in the garrison, and about one third of the men were on sick report. On the morning report for April 25th the Confederates had 263 men for duty.

During the night, 25-26th, the Federal batteries were completely repaired and the magazines replenished. The men slept at the batteries so that they might open fire again if necessary.

After communicating with General Burnside during the night of the 25th, on the morning of the 26th at 9:30 a.m. the fort and the garrison surrendered to General Parke as prisoners of war on parole till properly exchanged.

The three Federal batteries had been in action ten and a half hours, and had fired 1100 shot and shell, of which 560 struck the fort, dismounting some 17 guns, disabling others, and killing 8 men and wounding 26.

The Federal losses were 1 man killed at Flagler's battery, and 2 wounded at Morris' battery.

"Flagler's battery" was commanded by Lieutenant D. W. Flagler, Ordnance Department, and was manned by detachments of two companies, the men having no previous knowledge of mortar practice except what they had gained from a drill the previous day; yet it was said they served the pieces

* During the bombardment a detachment of the Signal Corps under Lieutenant W. S. Andrews rendered most important assistance to the commanders of batteries; for his position being nearly at right angles to the line of fire, early in the action he noted 10-inch shells going 300 yards beyond the fort and 8-inch shells falling short. By the signalling of his observations, the elevations of the pieces were corrected, so that after 12 o'clock every projectile from the mortars fell into the fort.

(See report of Lieutenant W. S. Andrews, 9th N. Y. Infantry, pp. 291-292, vol. ix, Series I, *Official Records of the Union and Confederate Armies.*)

efficiently and without accident throughout the day. Four gunners had been detailed from Captain Morris' company.

The 8-inch mortar battery was under charge of Lieutenant M. F. Prouty, a volunteer officer of infantry, and did excellent work. Lieutenant Prouty had no knowledge of artillery except what he had gained after reporting at the battery for duty on April 24th. He had under him two officers and fifteen men of the 3rd New York Artillery and five men from Captain Morris' company.

Besides the batteries already mentioned there were also two floating batteries carrying 4 rifled 30-pounder Parrott guns and 1 12-pounder; but only one floating battery participated in the fire.

As to the fire of the guns, that of the Parrott guns was most destructive, the three pieces disabling many of the Confederate guns. Notwithstanding the fact that they could reach only three feet in width along the top of the scarp wall of the western face, yet in this narrow portion 41 of their shots took effect, some of them penetrating the brick masonry to a depth of two feet. The Parrott guns fired 450 shot and shell, and because of their rapid and continuous fire all vents were enlarged—one so much so as to render the gun unserviceable. Several traverse circles were blown up by mortar shell, which, however, do not seem in any other way to have disabled guns. Forty-eight mortar shells exploded in the bottom of the ditch and a large number on the parade.

Of the Confederate fire, 2 shells burst over the 8-inch battery; 6 32-pounder shot passed through the embrasures of the Parrott gun battery, one striking a gun, but without disabling it; and a 10-inch shell struck a wheel of a limber and shattered it.

Of the ships of the fleet the report is as follows:

The *Chippewa* fired 32 rounds; the *Gemsbok* 28. The *Chippewa* had a shot pass through the rigging and exploded, but sustained no damage. The *Gemsbok* was hit once, losing some stays and halyards. The *Daylight* was hit once. The *State of Georgia* had a shot pass through the ensign. Of ammunition expended aboard the *Daylight* and the *State of Georgia* there is no record.

The fort was much damaged and it is said in the Confederate reports that "two days more of such firing would have reduced the whole to a mere mass of ruins."

With the fort were surrendered 54 guns, a large amount of ammunition, 400 prisoners, 500 rifles, 40 horses, etc.

The result of this action was to open one of the best harbors on the southern coast and to complete the work of the Coast Division, otherwise known as the Burnside Expedition.

## Comments

1. A good example, though on a small scale, of a combined military and naval attack on fortifications, affording an example of a type attack. The naval vessels fought a containing action and gave the land forces better opportunity to do their work.
2. The naval commander, responding to the sound of the guns without waiting for orders to engage, rendered good service, whereas, had he awaited instructions from land, his cooperation would not have been had.
3. The fort had not been built nor armed for defense against land attack; otherwise the siege would have lasted longer.
4. The Confederate fire was able to inflict but little damage on the besieging batteries, owing to its very limited sector caused by narrowness of embrasure.
5. An example of proper use of terrane in locating batteries.
6. Mortars and guns were worked by personnel having but little artillery experience.
7. A good example of correcting overs and shorts by observation of fire, made possible in this case by the position of the guns and the target relative to a point of observation.

## Authorities

*Official Records of the Union and Confederate Armies*, Series I, Vol. IX, pages 270-294, and Atlas.

*Official Records of the Union and Confederate Navies*, Series I, Vol. VII, pages 205, 247, and 277-283.

*Battles and Leaders of the Civil War*, Vol. I, pages 636, 652-4, and 669.

*Harper's Pictorial History of the Civil War*, page 249.

# PROFESSIONAL NOTES

## THE DETERMINATION OF THE COEFFICIENT OF FORM OF PROJECTILES BASED ON THEORETICAL CONSIDERATIONS

Translated from the Italian of Giuliano Ricci, Lieutenant Colonel of Artillery

The determination of the coefficient of form of a given projectile is of greater importance today than formerly, owing to the adoption for artillery projectiles of the sharp pointed head first employed for rifle bullets. Indeed, so uncertain is the behavior of the projectile in its flight and the manner in which the air resistance acts upon it, and so numerous the various errors to be compensated (all of which are combined in the coefficient of form), that it might, as stated by Cranz,* be more properly called the coefficient of ignorance.

Certainly, in the present development of the science of ballistics the exact value of the coefficient of form defies calculation, if not experimental determination.

However, there are a number of theoretical hypotheses which, though differing greatly among themselves and lacking in accuracy, yet give an idea of the manner in which the coefficient varies. There are also empirical rules and experimental results which furnish more or less reliable values or indications.

We aim in this article to state briefly the methods of calculation resulting from these hypotheses and to give the data usually obtained for determining the theoretical value of the coefficient; that is, for determining its value based on the geometrical character of the projectile independently of the results of fire.

Some of this data would seem wholly inadmissible and may be definitely discarded: other, though lacking in accuracy and therefore questionable, may ultimately furnish some general criterion or some useful indication, or at least a point of departure for the theoretical or practical determination of results more approximate and reliable.

Before proceeding to the calculations which give the coefficient of form, we deem it important to note briefly and to discuss the principal hypotheses which serve as a basis for these calculations.

When, as is usual, the coefficient of form is made to depend solely on the head of the projectile, it is assumed that the latter always moves so as to maintain its axis tangent to the trajectory. Generally, the angle between the tangent and the axis will be very small, since the projectile which fails to satisfy this condition must be immediately rejected. It cannot be denied, however, that in certain cases the angle may be large enough to have a considerable influence upon the resistance encountered by the projectile in the air. The coefficient would then depend, not only upon the head of the projectile, but also upon the distribution of its mass (position of the center of gravity, moment of inertia), upon the velocity of translation and that of

*Lehrbuch der Ballistik, Vol. 1, p. 73.

rotation, and, generally, upon all the causes on which depend the movements of precession and nutation which the axis of the projectile assumes. None of these elements are taken into account, owing to the serious complications which would be encountered in calculation and because their action can often be approximately estimated.

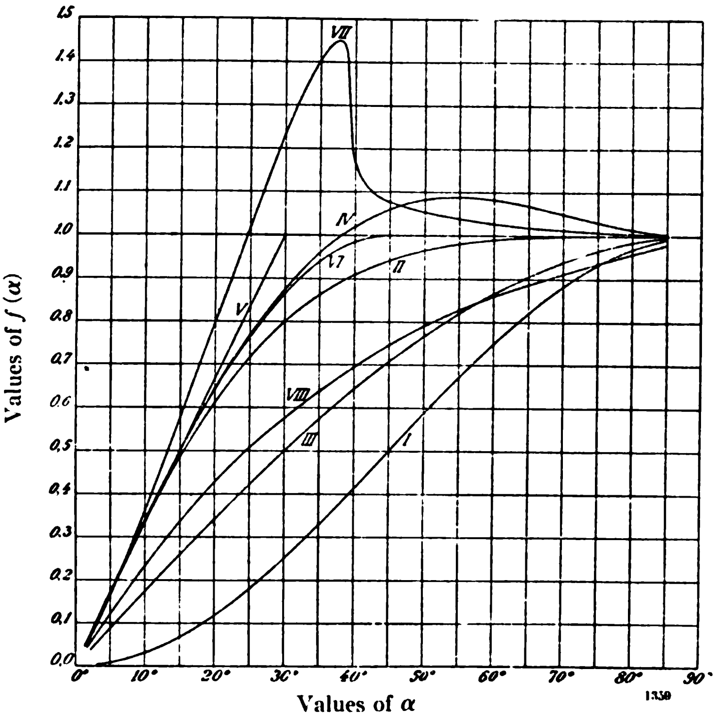



FIG. 1.

I Newton—II Duchemin—III v. Lössl—IV Renard—V Eiffel—VI Riabouchinsky—VII Eiffel's experiment—VIII Eiffel for dihedral angles.

It is assumed that the resistance encountered by a thin plate moving in the air and making an angle $\alpha$ with the direction of motion, is a definite function of this angle. To be more precise, denoting by $P_\alpha$ the resistance encountered by the plate and by $P_{90°}$ the corresponding resistance of the plate for $\alpha = 90°$, it is assumed that

$$\frac{P_\alpha}{P_{90°}} = f(\alpha)$$

Various expressions for the function of $\alpha$ have been proposed from time to time.* We give here the following:†

*The study of the resistance of the air has recently received a strong impulse owing to its relation to aviation. See, among other publications on this subject, "*The Resistance of the Air*" and "*The Resistance of the Air and Aviation,*" by Eiffel. Most of the figures and data of this article are taken from the latter work.

†In publications which treat of the resistance of the air, both recent and for some years back, fourteen such formulas are given; in addition, the results of numerous experiments have also been expressed in formulas. The values of $f(\alpha)$ vary between wide limits.

$$f(\alpha) = \sin^2 \alpha \quad \ldots\ldots \quad \text{(Newton-1687)}$$

$$" \quad = \frac{2 \sin \alpha}{1 + \sin^2 \alpha} \quad \ldots\ldots \quad \text{(Duchemin-1842)}$$

$$" \quad = \sin \alpha \quad \ldots\ldots \quad \text{(v. Lössl-1876)}$$

$$" \quad = 2 \sin \alpha - \sin^3 \alpha \quad \ldots\ldots \quad \text{(Renard-1889)}$$

$$\left.\begin{array}{l} " \quad = \frac{\alpha}{30^\circ} \text{ for } \alpha < 30^\circ \\ " \quad = 1 \text{ for } \alpha > 30^\circ \end{array}\right\} \quad \ldots\ldots \quad \text{(Eiffel-1907)}$$

$$\left.\begin{array}{l} " \quad = \sin 2\alpha \text{ for } \alpha < 45^\circ \\ " \quad = 1 \quad\;\; \text{ for } \alpha > 45^\circ \end{array}\right\} \quad \ldots\ldots \quad \text{(Riabouchinsky-1909)}$$

The curves of Fig. 1 show the values of $f(\alpha)$ for the different formulas.

For a curved surface like the head of a projectile, the total resistance is obtained by summation by integration of the partial resistances of the various elements of the surface considered as if they were isolated.

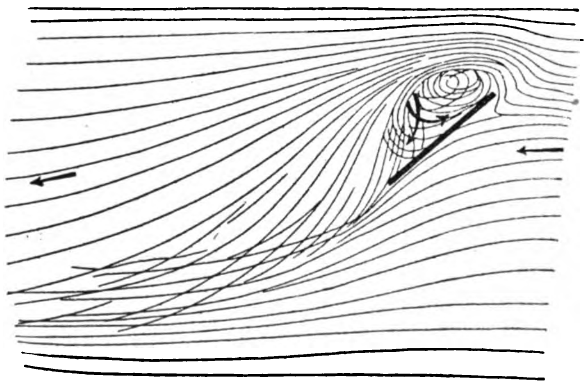


FIG. 2. 1300

$\alpha = 40^\circ$

Now, in the first place, it should be observed that the formulas given above and all others of a similar nature which may be deduced, reproduce more or less accurately the real values of the ratio $\frac{P_\alpha}{P_{90^\circ}}$. The recent experiments of Eiffel and others have shown that the curve of values of this ratio has a very definite trace, different, in fact, from all those previously seen (see curve 7, Fig. 1, obtained with a plane 0.25×0.25 cm.).

The formulas, or curves which represent them, indicate also the total pressure encountered by the plate; the latter, however, is due to a rather complex action of the air.

Fig. 2 and Figs. 2a and 2b* show that, owing especially to the vacuum formed behind the plate and the manner in which the fluid flows around the latter to fill that vacuum, at least partially, the pressure must vary from point to point on the front surface, and that the rear surface must be subjected to

* Figs. 2a and 2b reproduce the results of experiments made at the aerodynamic institute of Koutchino by Riabouchinsky. In these experiments, as in those of Eiffel and many others, the surface whose resistance was sought was fixed and subjected to a current of air. According to Eiffel and many investigators (but not all), the results thus obtained ought to be identical with those that would be obtained were the surface moved in still air.

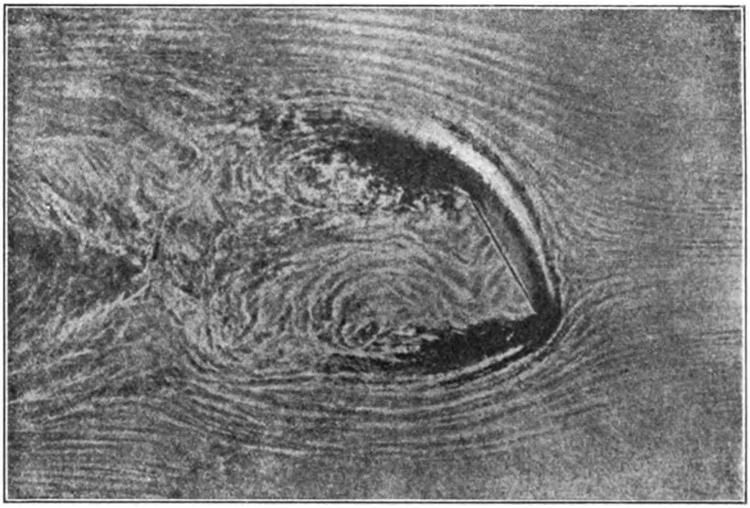


FIG. 2a. 1361
$\alpha = 60°$

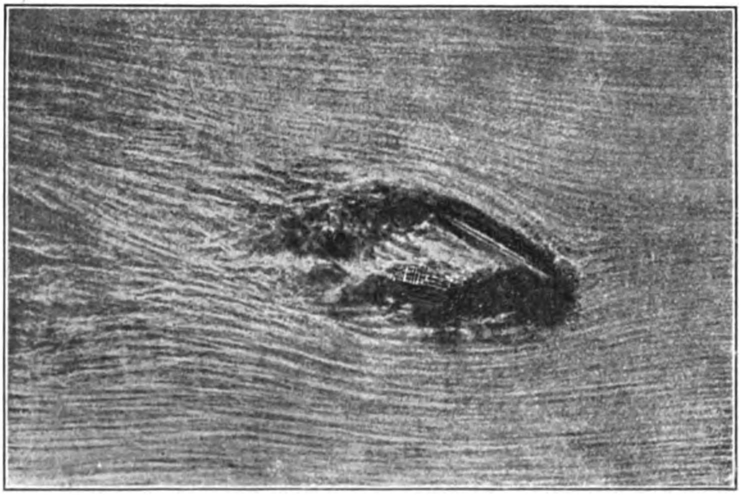


FIG. 2b. 1362
$\alpha = 30°$

a negative pressure which also varies from point to point. Curve (a) of Fig. 3 indicates in what proportion, depending on the different values of $\alpha$, the total pressure is derived from the pressure in front and the back-pressure in rear. (Square plate .50 × .50 cm., velocity 10 m. per minute.)

Fig. 4 shows more precisely how the pressure is distributed at the various points of the front and rear surfaces for the two cases of $\alpha = 20°$ and $\alpha = 60°$ (plate and velocity same as before: the pressures are indicated in kg. per square meter).

By varying the dimensions and form of the surface subjected to test, the conditions governing the action of the fluid also varies; the distribution of the pressure will consequently be different and therefore the total pressure will also be different.

Thus, according to Eiffel's experiments, when the motion is normal to the surface of the plate, the pressure per unit of surface increases in the proportion of 8 to 1, in passing from a square plate .10 × .10 m. to a plate 1 × 1 m. and over.*

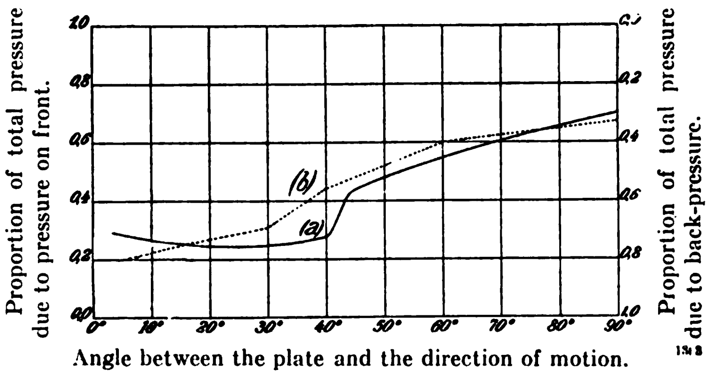



FIG. 3.

The pressure increases also in the proportion of .7 to 1 in passing from square planes to rectangular ones having sides whose ratio increases up to 50 to 1. (Longer side normal to the direction of motion.)

Fig. 5 gives the value of the ratio of $\frac{P_\alpha}{P_{90°}}$ for inclined rectangles of different "lengths."†

Curve (b) of Fig. 3 shows the distribution of the total pressure on the front and rear faces in the case of a rectangle .85 × .15 cm. (Longer side normal to the direction of motion.) Fig. 6, like Fig. 4, represents the distribution of the pressure at the different points of the front and rear surfaces for the rectangular plane referred to above.

* According to Soreau, if $S$ be the area of the surface subjected to experiment, the pressure per unit of area will be proportional to $S^{0.06}$ and will tend towards a fixed limit for the larger surfaces. We do not know whether this law is also true for surfaces varying within the limits which include the areas of right sections of projectiles and for ballistic velocities. If this law holds, it would be inaccurate to assume that the resistance encountered by a projectile is proportional to the area of its cross section. For example, the resistance per unit of area encountered by a 305 mm. projectile would be 1.6 times greater than that encountered by a 0.0065 mm. rifle ball. This difference is much too great; it is quite probable, however, that the resistance per unit of area for the rifle ball is less than that of the large projectile.

† By "length" is here meant the ratio of the edge normal to the motion to the other edge.

If two plates united to form a dihedral angle be substituted for the single plate, the resistance acts quite differently.

The phenomena for dihedral angles recently observed by Bouasse* has no *a priori* relation with thé phenomena observed for two separate single plates. Their junction completely changes the lines of fluid current due to each of them.

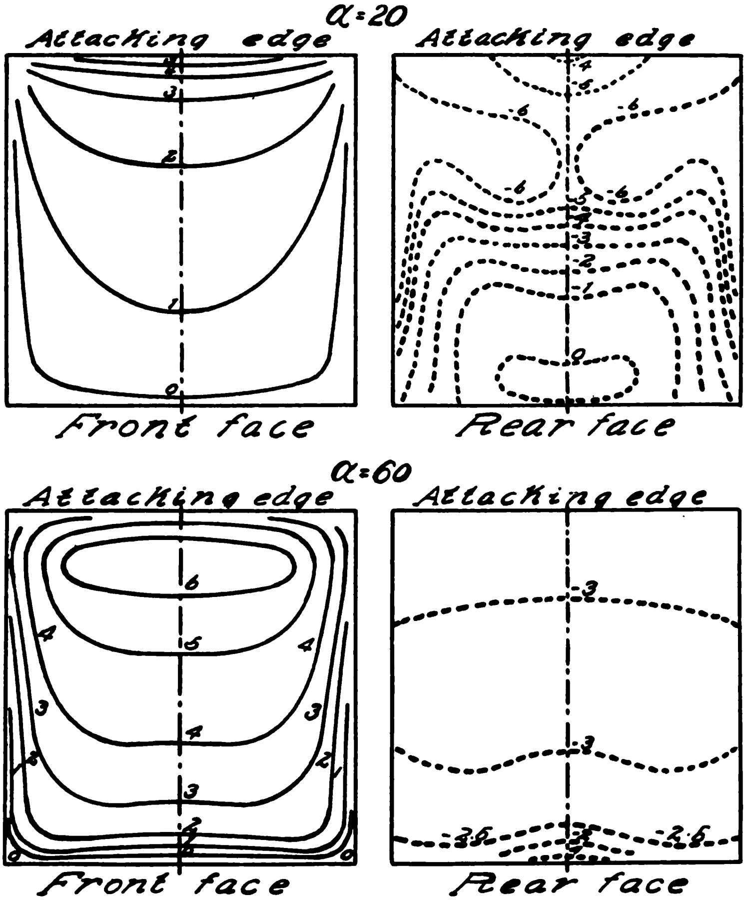



Fig. 4.

Curve VIII of Fig. 1 indicates, according to Eiffel's experiments, the resistance made by a dihedral of aperture $2\alpha$ when the motion is in the direction of the bisector plane.

The manner in which the details of the phenomena vary when any of the conditions producing them are changed, still referring to plane surfaces, may give an idea of the greater complication which may arise for a curved surface like the head of a projectile. In addition, the ballistic velocities, being so much greater than those adopted in the experiments relating to aviation,

* *Cours de Mecanique-Physique*, vol. I, p. 382.

must contribute to give the phenomena a special character. These are not well known; but, on the whole, it is probable that the molecules of air corresponding to a very small element of the surface of the projectile will not act upon it as if it had considerable dimensions—and were isolated; it will lack, among other things, the back pressure upon the rear face of the element. On the other hand, these molecules will react upon the others hurled back from the adjacent elements, thus modifying the resistance which they, considered separately, would have encountered.

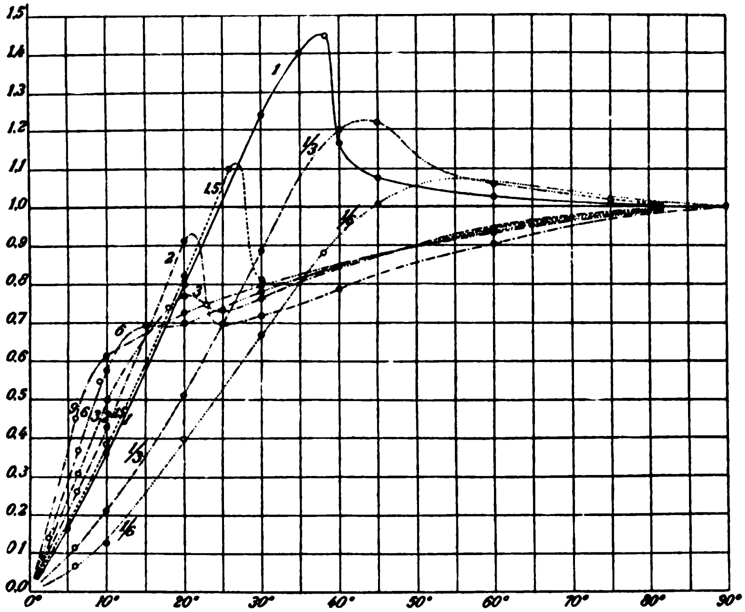



FIG. 5. 1365

| | | | | |
|---|---|---|---|---|
| plate | 25 | x 25, | "length" | 1 |
| " | 22.5 | x 15, | " | 1.5 |
| " | 30 | x 15, | " | 2 |
| " | 45 | x 15, | " | 3 |
| " | 90 | x 15, | " | 6 |
| " | 90 | x 10, | " | 9 |
| " | 15 | x 45, | " | 1/3 |
| " | 15 | x 90, | " | 1/6 |

The details of the phenomena will vary, not only according to the form of the head and the caliber, but also, in the same projectile, according to the distance of the element considered from the axis, the velocity, etc. And yet the calculation cannot take account of these conditions of fact.

Even admitting that the axis of the projectile is tangent to the trajectory, the part of the projectile which is in rear of the plane of the base of the ogive exerts an influence upon the total resistance. Upon it depends, in fact, the positive or negative pressure exerted by the fluid around and behind the projectile which is similar to what happens for a thin plate.

This fact, utilized as a basis for theoretical considerations by Robin and

d'Alembert,* is largely confirmed by experiment, but cannot be subjected to rigorous calculation.

Notwithstanding these causes of inaccuracy, which at first sight would appear most serious, the calculations furnish results which vary much less from those obtained in firing than would appear possible. Perhaps this is due to the fact that sometimes the error committed is compensated, at least in part, by others. Moreover it should be noted that it is not necessary to determine the resistance $\rho$ encountered by a given projectile, but the ratio $\frac{\rho}{\rho_1}$

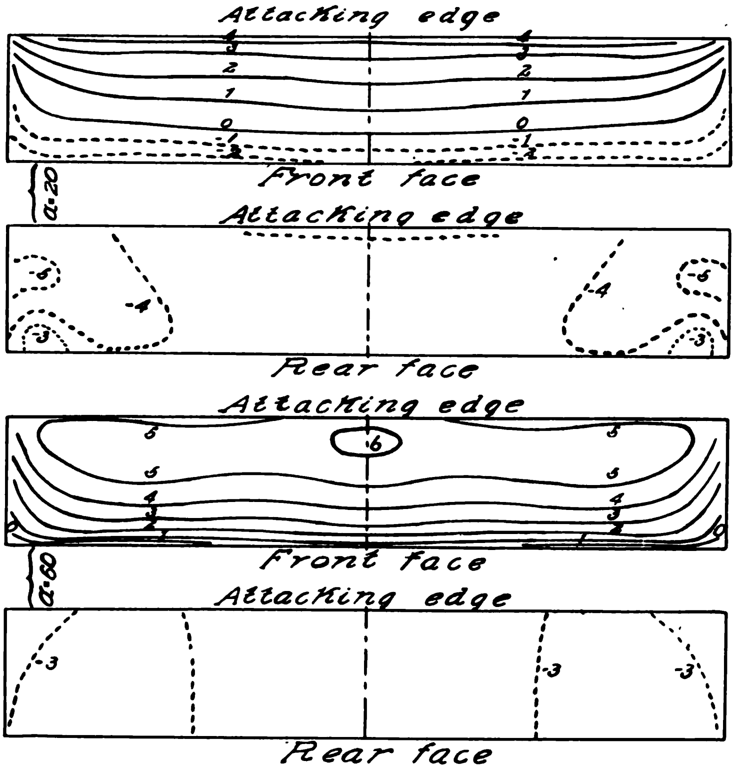



FIG. 6. 1366

between that resistance and that corresponding to another type of projectile. Moreover, even if the calculated values of $\rho$ and $\rho_1$ differ very materially from those obtained experimentally, it does not necessarily follow that the ratio $\frac{\rho}{\rho_1}$ is greatly in error. This is, in fact, realized within certain limits when a suitable formula of resistance is adopted for the calculation of $\rho$.

These considerations explain, in a measure, the use which may be made of calculation in determining the coefficient of form.

* Robin.—*New Principles of Gunnery.* (1742.)
D'Alembert.—*Traite de l'equilibre et du mouvement des fluides.* (1744.)

In order to calculate, in the manner indicated above, the resistance encountered by the projectile, we have applied in succession the expressions for $f(\alpha)$ given by Newton, by Duchemin, and by v. Lössl, which have previously been used for this purpose in ballistics.

Newton's law is certainly the most inaccurate, being farthest from the results of all experiments; it has been used for a long time and it seems interesting to us to see the results to which it leads.

Duchemin's law accords more nearly with others of more recent date, particularly for values of $\alpha$ exceeding 40°, the limit usually adopted for the heads of ogival projectiles.

V. Lössl's law when applied to a plane indicates pressures certainly less than the real ones: but it is seen from Fig. 1 that it is very near that found by Eiffel for two planes united to form a dihedral angle: similarly for projectiles, it furnishes results approaching more nearly those actually obtained in firing than do the other formulas.

With any of these formulas or others which may be adopted, the calculation leads to a relation which may generally be expressed by

$$\rho = K.\pi R^2.F$$

in which $\rho$ is the resistance actually encountered by the projectile moving in the direction of its axis with the given velocity; $K$ is the resistance that would be encountered by a plane surface of unit area moving with the same velocity in the direction normal to its surface; $R$ is the radius of the cross section of the projectile; $F$ is a coefficient which varies according to the hypothesis adopted, and for each hypothesis it depends upon the form of the head and is a function of its elements; in other words, it is the ratio between the resistance $\rho$ encountered by the projectile and that which would be encountered by a thin plane plate having an area equal to the cross section of the projectile.

To find the coefficient of form of a given projectile, it suffices to calculate the value of $F$ corresponding to it and divide the result by the $F$ relating to the typical projectile for which the coefficient is assumed to be unity.

To calculate $F$, we have the formulas of Table I, corresponding, for each hypothesis, to different forms of head. In these formulas $a$ represents the length of the head of the projectile expressed in calibers, $n$, for the ogival head, the radius of the generating circle of the ogive, also expressed in calibers. The following relation exists between $a$ and $n$:

$$a = \tfrac{1}{2}\sqrt{4n-1}$$

or

$$n = \frac{4a^2+1}{4}.$$

The demonstration of formula [2] will be found in Bianchi, *Balistica Esterna*, p. 25. Formulas [4], [5], and [6], were given by Ingalls in an article published in the Journal of the United States Artillery, and reprinted in the *Revista* (1896, vol. 1, p. 131). Formula [8] is a simple transformation of that given by Cranz (*Ballistik*, vol. I, p. 70). The demonstration of the other formulas does not differ. We nevertheless give them here briefly.

Starting with Newton's hypothesis, the component of the pressure upon an elementary zone $m\ n\ n_1\ m_1$ (Fig. 7) of the surface of the head in the direction of motion, is given by

$$K.\ 2\pi x\ ds\ \sin^3\alpha$$

TABLE I.

| | Newton | Duchemin | v. Lössl |
|---|---|---|---|
| Conical head | $F=\frac{1}{1+4a^2}$ [1] | $F=\frac{\sqrt{4a^2+1}}{2a^2+1}$ [4] | $F=\frac{1}{\sqrt{1+4a^2}}$ [7] |
| Ogival head | $F=\frac{8n-1}{24n^2}$ [2] | $F=4n\left\{2\sqrt{4n-1}-4n\tan^{-1}\frac{\sqrt{4n-1}}{2n}+\right.$ $+2(2n-1)\tan^{-1}\frac{2n-1}{\sqrt{4n-1}}-$ $-\frac{2(2n-1)}{\sqrt{2}}\tan^{-1}\frac{2n-1}{\sqrt{2}\sqrt{4n-1}}-$ $\left.-(2n-1)(2-\sqrt{2})\frac{\pi}{2}\right\}$ [5] | $F=2n\sqrt{4n-1}-$ $-\frac{1}{6n}\sqrt{(4n-1)^3}-$ $-2n(2n-1)\sin^{-1}\frac{\sqrt{4n-1}}{2n}$ [8] |
| | or, | or, | or, |
| | $F=\frac{2}{3}\frac{1+8a^2}{(1+4a^2)^2}$ [2bis] | $F=(4a^2+1)\left\{4a-(4a^2+1)\tan^{-1}\frac{4a}{4a^2+1}+\right.$ $+(4a^2-1)\tan^{-1}\frac{4a^2-1}{4a}-$ $-\frac{4a^2-1}{\sqrt{2}}\tan^{-1}\frac{4a^2-1}{4a\sqrt{2}}-$ $\left.-\frac{4a^2-1}{4}(2-\sqrt{2})\pi\right\}$ [5bis] | $F=(a^2+1)a-\frac{2}{3}\frac{8a^3}{4a^2+1}-$ $-\frac{16a^4-1}{4}\sin^{-1}\frac{4a}{4a^2+1}$ [8bis] |
| Paraboloidal head | $F=\frac{1}{16a^2}\log(1+16a^2)$ [3] | $F=\frac{1}{4a^2}\left(\sqrt{1+16a^2}-\right.$ $\left.-\tan^{-1}\sqrt{1+16a^2}-1+\frac{\pi}{4}\right)$ [6] | $F=\frac{1}{8a^2}(\sqrt{1+16a^2}-1)$ [9] |

in which $\alpha$ is the angle between the tangent to the generating curve of the head at the point considered and the direction of motion. From the figure we have

$$\sin\alpha = \frac{dx}{ds}$$

whence,

$$\rho = K.\,2\pi \int_0^R \frac{x\,dx}{1+\frac{dy^2}{dx^2}}$$

The value of $\frac{dy}{dx}$ is deduced from the equation of the generatrix of the head. In the case of a conical head (Fig. 8),

$$\frac{dy}{dx} = -\frac{l}{R}$$

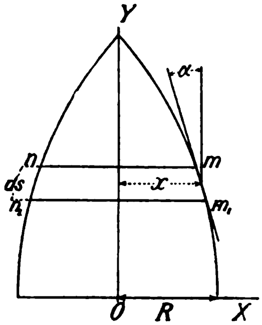



FIG. 7. 1367

whence,

$$\rho = K.\,2\pi \int_0^R \frac{x\,dx}{1+\frac{l^2}{R^2}}$$

$$= K\pi R^2 \frac{1}{1+\frac{l^2}{R^2}}$$

making,

$$\frac{l}{2R} = a$$

$$\rho = K\pi R^2 \frac{1}{1+4a^2}$$

$$F = \frac{1}{1+4a^2} \qquad [1]$$

For a parabolic head (Fig. 9) the equation of the generatrix is

$$y = l - \frac{l}{R^2}x^2$$

whence,

$$\frac{dy}{dx} = -\frac{2l}{R^2}x$$

and,

$$\rho = K.\ 2\pi \int_0^R \frac{x\,dx}{1+4\frac{l^2}{R^4}x^2}$$

performing the integration, we have:

$$\rho = K.\ \pi R^2.\ \frac{R^2}{4l^2}\log\left(1+\frac{4l^2}{R^2}\right)$$

and making,

$$a = \frac{l}{2R}$$

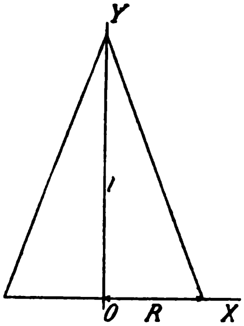



FIG. 8.

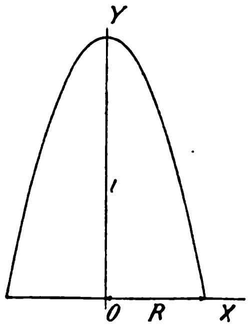



FIG. 9. 1368

we have,

$$\rho = K.\ \pi R^2.\frac{1}{16a^2}\log\left(1+16a^2\right)$$

and,

$$F = \frac{1}{16a^2}\log\left(1+16a^2\right) \qquad [ε]$$

Taking v. Lössl's formula, the component noted above is expressed by,

$$K.\ 2\pi\ x\ ds \sin^2\alpha$$

whence,

$$\rho = K.\ 2\pi \int_0^R \frac{x\,dx}{\sqrt{1+\frac{dy^2}{dx^2}}}$$

For a conical head we have:

$$\rho = K.\ 2\pi \int_0^R \frac{x\,dx}{\sqrt{1+\frac{l^2}{R^2}}}$$

$$= K.\ \pi R^2 \frac{1}{\sqrt{1+\frac{l^2}{R^2}}}$$

$$F = \frac{1}{\sqrt{1+4a^2}} \qquad [7]$$

For the parabolic head we have:

$$\rho = K \cdot 2\pi \int_0^R \frac{x\,dx}{\sqrt{1+\frac{4l^2}{R^4}x^2}}$$

$$= K \cdot \pi R^2 \cdot \frac{R^2}{2l^2}\left(\sqrt{1+4\frac{l^2}{R^2}}-1\right)$$

$$= K \cdot \pi R^2 \cdot \frac{1}{8a^2}\left(\sqrt{1+16a^2}-1\right)$$

$$F = \frac{1}{8a^2}\left(\sqrt{1+16a^2}-1\right) \qquad [9]$$

By means of the formulas given in Table I, we have calculated the values of $F$ for different values of $a$ and $n$ (Table II), and have divided the results by the values of $F$ corresponding to the different hypotheses assumed for the ogival head having a radius of 1½ calibers, since the ballistic tables in use by us [in Italy] are calculated for this type of projectile.* The results obtained are given in Table III.

In addition to the values of the coefficient of form obtained by calculation based on the special hypotheses relating to the resistance of the air, we may quote those deduced from some empirical laws which represent the final results obtained experimentally. In France lately it has been assumed, as an approximate rule proposed by Hélie, that the resistance of ogival headed projectiles is proportional to the sine of the semi-angle at the apex, $\gamma$.

For an ogive described with a radius of $n$ calibers or $a$ calibers long we have †

$$\sin \gamma = \frac{\sqrt{4n-1}}{2n}$$

$$\sin \gamma = \frac{4a}{1+4a^2}$$

For projectiles having an ogive described with a radius of 1½ calibers,

$$\sin \gamma = \frac{\sqrt{5}}{3}$$

whence the coefficient of form $i$ will be given by the formula

$$i = \frac{3\sqrt{4n-1}}{2n\sqrt{5}} = 0.6708\,\frac{\sqrt{4n-1}}{n}$$

or,

$$i = \frac{12a}{(1+4a^2)\sqrt{5}} = 5.3666 \cdot \frac{a}{1+4a^2}$$

* As is known, the type projectile abroad, for which the coefficient of form is unity, is one the ogive of which has a radius of 2 calibers.

† From these two equations we find

$$n = \frac{1}{4\sin^2\frac{\gamma}{2}} \text{ and } a = \frac{1}{\tan^2\frac{\gamma}{2}}$$

TABLE II. Values of $F$.

| $n$ | $a$ | Newton | | | Duchemin | | | v. Lössl | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | cone | ogive | paraboloid | cone | ogive | paraboloid | cone | ogive | paraboloid |
| 0.50 * | 0.50 | 0.500 | 0.500 | 0.402 | 0.943 | 0.858 | 0.871 | 0.707 | 0.666 | 0.618 |
| 0.8125 | 0.75 | 0.308 | 0.347 | 0.256 | 0.848 | 0.788 | 0.748 | 0.555 | 0.551 | 0.480 |
| 1.25 | 1.00 | 0.200 | 0.240 | 0.177 | 0.745 | 0.711 | 0.644 | 0.447 | 0.456 | 0.390 |
| 1.5 | 1.118 | 0.167 | 0.203 | 0.150 | 0.700 | 0.675 | 0.602 | 0.408 | 0.419 | 0.358 |
| 1.8125 | 1.25 | 0.138 | 0.171 | 0.130 | 0.653 | 0.637 | 0.561 | 0.372 | 0.384 | 0.327 |
| 2.50 | 1.50 | 0.100 | 0.126 | 0.100 | 0.575 | 0.571 | 0.496 | 0.316 | 0.331 | 0.282 |
| 3.3125 | 1.75 | 0.075 | 0.097 | 0.079 | 0.511 | 0.513 | 0.443 | 0.274 | 0.288 | 0.248 |
| 4.25 | 2.00 | 0.059 | 0.076 | 0.065 | 0.458 | 0.466 | 0.400 | 0.243 | 0.255 | 0.221 |
| 5.3125 | 2.25 | 0.047 | 0.061 | 0.054 | 0.414 | 0.427 | 0.364 | 0.217 | 0.230 | 0.198 |
| 6.50 | 2.50 | 0.038 | 0.050 | 0.046 | 0.378 | 0.392 | 0.334 | 0.195 | 0.209 | 0.181 |
| 7.8125 | 2.75 | 0.032 | 0.042 | 0.040 | 0.347 | 0.359 | 0.309 | 0.179 | 0.189 | 0.166 |
| 9.25 | 3.00 | 0.027 | 0.035 | 0.034 | 0.320 | 0.328 | 0.287 | 0.164 | 0.173 | 0.153 |

* Hemisphere.

Table III. Values of the Coefficient of Form.

| $n$ | $a$ | Newton | | | Duchemin | | | v. Lössl | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | cone | ogive | paraboloid | cone | ogive | paraboloid | cone | ogive | paraboloid |
| 0.50 | 0.50 | 2.463 | 2.463 | 1.980 | 1.397 | 1.271 | 1.290 | 1.688 | 1.590 | 1.475 |
| 0.8125 | 0.75 | 1.517 | 1.709 | 1.261 | 1.256 | 1.167 | 1.108 | 1.325 | 1.315 | 1.146 |
| 1.25 | 1.00 | 0.985 | 1.182 | 0.872 | 1.104 | 1.053 | 0.954 | 1.067 | 1.088 | 0.931 |
| 1.50 | 1.118 | 0.823 | 1.000 | 0.739 | 1.037 | 1.000 | 0.872 | 0.974 | 1.000 | 0.854 |
| 1.8125 | 1.25 | 0.680 | 0.842 | 0.640 | 0.967 | 0.944 | 0.831 | 0.888 | 0.916 | 0.780 |
| 2.50 | 1.50 | 0.493 | 0.621 | 0.493 | 0.852 | 0.846 | 0.735 | 0.754 | 0.789 | 0.673 |
| 3.3125 | 1.75 | 0.369 | 0.478 | 0.389 | 0.757 | 0.760 | 0.656 | 0.654 | 0.687 | 0.592 |
| 4.25 | 2.00 | 0.291 | 0.374 | 0.320 | 0.678 | 0.690 | 0.593 | 0.580 | 0.609 | 0.527 |
| 5.3125 | 2.25 | 0.231 | 0.300 | 0.266 | 0.613 | 0.633 | 0.539 | 0.518 | 0.549 | 0.473 |
| 6.50 | 2.50 | 0.187 | 0.246 | 0.227 | 0.560 | 0.581 | 0.495 | 0.465 | 0.499 | 0.432 |
| 7.8125 | 2.75 | 0.158 | 0.207 | 0.197 | 0.514 | 0.532 | 0.458 | 0.427 | 0.451 | 0.396 |
| 9.25 | 3.00 | 0.133 | 0.172 | 0.167 | 0.474 | 0.486 | 0.425 | 0.391 | 0.413 | 0.365 |

The data in Table IV has been calculated by this formula.*

Captain Alston Hamilton (United States) states that from experiments executed in America and France the resistance is proportional to the mean value of the sine of the angle between the tangent to the surface of the head and the axis of the projectile.† He also shows that this is equivalent to assuming the resistance inversely proportional to the surface of the head. Evidently it is a question of an empirical law which can have no value beyond the limits within which it has been established But Hamilton states that it is confirmed by experiments with projectiles having an ogive described with a radius up to 7 calibers.

Hamilton gives the formula relating to this law for ogival heads only, but assumes that the same law may be applied to parabolic heads or heads of any other form.

Denoting by $S_c$, $S_o$, and $S_p$, respectively, the surfaces of a conical, ogival, and parabolic head (paraboloid of revolution), and preserving the notation adopted in formulas [1] to [9], we have:

$$S_c = \pi R^2 \sqrt{1+4a^2} \tag{10}$$

$$S_0 = \pi R^2 \cdot 4n\left(\sqrt{4n-1} - (2n-1)\sin^{-1}\frac{\sqrt{4n-1}}{2n}\right) \tag{11}$$

or,

$$S_o = \pi R^2 \cdot (4a^2+1)\left(2a - \frac{4a^2-1}{2}\right)\sin^{-1}\frac{4a}{4a^2+1} \tag{11½}$$

$$S_o = \pi R^2 \cdot \frac{(16a^2+1)^{\frac{3}{2}} - 1}{24a^2} \tag{12}$$

for, $n=1.5$, [11] becomes

$$S_{1.5} = \pi R^2 \cdot 6\left(\sqrt{5} - 2\sin^{-1}\frac{\sqrt{5}}{3}\right)$$
$$= \pi R^2 \cdot 3.32356$$

Dividing $S_{1.5}$ by the values found by equations [10], [11], [12], we obtain the values of $i$ given in Table IV.

We also quote the very simple relation which Captain Hardcastle has suggested as sufficient to represent the whole of the coefficient of form.‡

He proposes to assume this coefficient as inversely proportional to the square root of the length of the head measured in calibers; that is proportional to

$$\frac{1}{\sqrt{a}}$$

or,

$$\sqrt[4]{\frac{4}{4n-1}}$$

* The *Text Book of Small Arms* (1909, p. 218) does not explicitly quote this law of the sine of the semi-angle, but it gives as sufficiently exact the formula:

$$i = \frac{2\sqrt{4n-1}}{n\sqrt{7}}$$

which exactly expresses this law if we assume a projectile the ogive of which has a radius of 2 calibers. The ballistic table given in the *Text Book* is calculated for just such projectiles.

† JOURNAL OF THE U. S. ARTILLERY, vol. xxx, p. 263.

‡ See *Journal of the Royal Artillery*, vol. 34, p. 385.

Taking, as usual, as a standard, the projectiles having an ogive for which $n$ equals 1.5 we have

$$i=\frac{\sqrt[4]{5}}{\sqrt{2a}}=\frac{1.0574}{\sqrt{a}}$$

or,

$$i=\sqrt[4]{\frac{5}{4n-1}}$$

and the values thus obtained are also given in Table IV.

TABLE IV.

Values of Coefficient of Form

| $n$ | $a$ | Hélie (ogive) | Alston Hamilton | | | Hard-castle |
|---|---|---|---|---|---|---|
| | | | cone | ogive | parabo-loid | |
| 0.50 | 0.50 | 1.342 | 2.350 | 1.662 | 1.959 | 1.495 |
| 0.8125 | 0.75 | 1.238 | 1.844 | 1.337 | 1.465 | 1.221 |
| 1.25 | 1.00 | 1.073 | 1.486 | 1.091 | 1.154 | 1.057 |
| 1.5 | 1.118 | 1.000 | 1.353 | 1.000 | 1.015 | 1.000 |
| 1.8125 | 1.25 | 0.925 | 1.234 | 0.913 | 0.947 | 0.946 |
| 2.50 | 1.50 | 0.805 | 1.051 | 0.780 | 0.801 | 0.863 |
| 3.3125 | 1.75 | 0.709 | 0.913 | 0.679 | 0.693 | 0.799 |
| 4.25 | 2.00 | 0.631 | 0.806 | 0.601 | 0.610 | 0.748 |
| 5.3125 | 2.25 | 0.568 | 0.721 | 0.538 | 0.544 | 0.705 |
| 6.50 | 2.50 | 0.516 | 0.652 | 0.487 | 0.492 | 0.669 |
| 7.8125 | 2.75 | 0.472 | 0.595 | 0.444 | 0.448 | 0.638 |
| 9.25 | 3.00 | 0.435 | 0.546 | 0.409 | 0.411 | 0.610 |

Based on the firing experiments had in Germany, Heydenreich has indicated a series of coefficients of form available for ogival heads described with radii increasing from 1 to 8 calibers; they are given in Table V.

TABLE V.

| $n$ | $a$ | $i$ |
|---|---|---|
| 0.5 | 0.5 | 1.350 |
| 0.7 | 0.671 | 1.200 |
| 1 | 0.866 | 1.100 |
| 1.5 | 1.118 | 1.000 |
| 2 | 1.323 | 0.950 |
| 3 | 1.658 | 0.850 |
| 4 | 1.936 | 0.800 |
| 6 | 2.398 | 0.700 |
| 8 | 2.784 | 0.650 |

Fig. 10 gives the curves representing the formulas and permits of comparing the values of the coefficient of form obtained for ogival heads from the

different formulas which they represent. It is evident that the curve deduced from Newton's law gives values for the coefficient of form which are too small and therefore inadmissible. It seems that the coefficient deduced from firing approaches closely those given by the group of curves of Hélie, v. Lössl, and Hamilton. At times, however, they are too large and approach the curve of Duchemin. Thus, for example, for the fusiform projectile, whose ogive is about 2½ calibers long, the coefficient is generally comprised

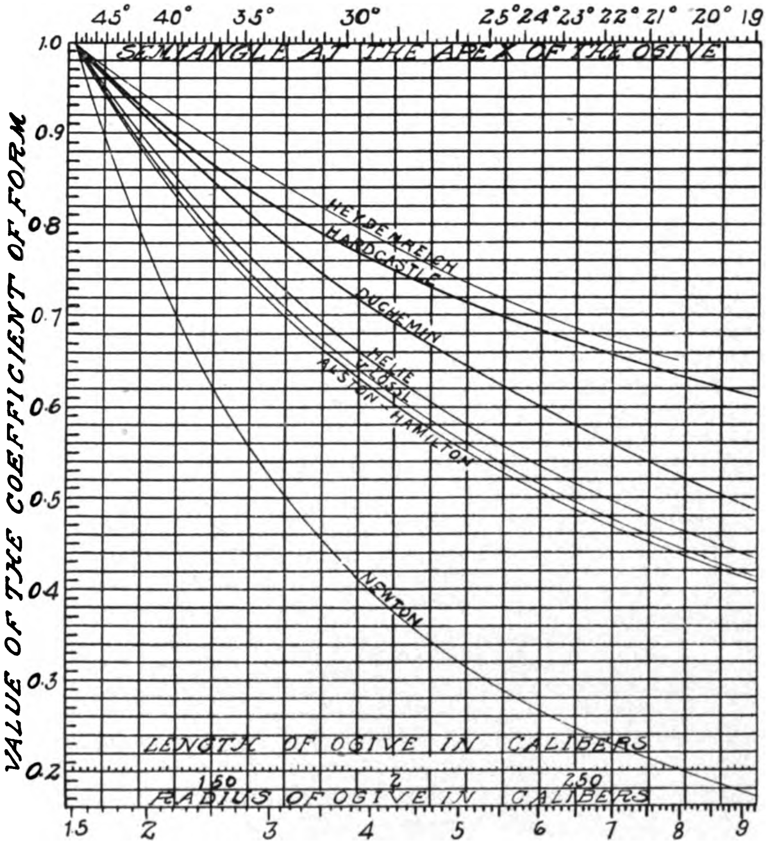



FIG. 10.

between .5 and .6. As has been noted in the beginning, however, even the values obtained in actual firing are uncertain; from the elements and from the results of firing in fact is deduced by calculation, not the true coefficient of form, but a coefficient of correction for a number of omissions, inaccuracies, and errors, due to the imperfections of the method.

The coefficient of form for equal lengths of head must vary according to the nature of the generating curve, as is easily perceived and as is deduced also from the formulas given. It is possible that the usual ogival form generated by an arc of a circle is not the best; the results given in Table III would show that the heads constituted by a paraboloid ought to be more

advantageous, and this perhaps is also confirmed by some practical results. This deduction is not certain but merits being verified by experiment.*

Many elaborate experiments have been conducted to measure the resistance encountered by bodies of different form moving in air.

It is to be noted, however, that in these experiments the velocity was some tens of meters, often even less than ten meters; the dimensions of the bodies experimented upon were also many times greater than those of projectiles. The value of the deductions which may be drawn from such experiments is therefore rather slight. Nevertheless, by a comparison of these results with those furnished by calculation we may perhaps derive some indications.

For a hemisphere the value of $F$ determined by calculation has been found to be .500, .858, .666, depending upon the formula adopted.

On the other hand, numerous experiments made at different times gave the following values, all considerably smaller:

.407 (Average of values obtained by Borda, Hutton, Vince),
.333 (v. Lössl),
.392 (Renard),
.32 (Eiffel).

These results would confirm the observation made above, that the different elements of the surface of the projectile do not encounter the resistance to which they would be subjected if the elements were isolated.

The following table gives the values for circular cones of different apertures as determined by experiment and as deduced from the various formulas: For a conical surface v. Lössl gives $F=.83 \sin\alpha$ ($\alpha$ is the semi-angle at the apex); but according to his law of resistance deduced for a plane, $F$ would be equal to the sine of $\alpha$.

| Experimenter | Semi-angle at the vertex | Length of head in calibers | Value of $F$ obtained | | | |
|---|---|---|---|---|---|---|
| | | | Experiment | Hypothesis of | | |
| | | | | Newton | Duchemin | v. Lössl |
| Borda | 45° | 0.500 | 0.691 | 0.500 | 0.943 | 0.707 |
| | 30° | 0.866 | 0.543 | 0.250 | 0.800 | 0.500 |
| Hutton | 25°42′ | 1.039 | 0.433 | 0.188 | 0.730 | 0.434 |
| Eiffel | 30° | 0.866 | 0.451 | 0.250 | 0.800 | 0.500 |
| | 15° | 1.866 | 0.300 | 0.067 | 0.485 | 0.259 |

For the ogive v. Lössl gives $F=0.5 (\sin\alpha)$, an expression which gives values of $F$ much smaller than those obtained from formula [8]. The same expression would indicate also that the ogive gives a considerably smaller resistance than the cone, contrary to the results given by calculation.

The differences in the values of $F$ obtained by different methods, give rise to rather small differences in the values of the coefficient of form, since

* The parabolic form was indicated as better than the ogival by Ingalls, who based his conclusions on Duchemin's formula (see article quoted).

As is known, the calculus of variations permits of investigating the form of the ogive of least resistance; this investigation has indeed been attempted, but the results are not yet available. (See *Revue d'Artillerie*, vol. 67, pp. 221 and 425, and Cranz, *Lehrbuch der Ballistik*, vol. 1, p. 77.)

in going from one method to another the resistance attributed to the type projectile taken as the standard will also vary in the same direction. Thus, for example, if we take for the ogival head $F=.50 \sin \alpha$, we obtain values much smaller than those given by [8]; but by that very simple expression the coefficient of form is equal to the sine of the semi-angle at the vertex according to the hypothesis of Hélie; now, as appears from Fig. 10, the curve which gives these values is very close to that which corresponds to formula [8]. On the whole, it seems that the values obtained on the hypothesis of v. Lössl approaches more nearly than the others those given by experiment, an observation which confirms that already made on the subject of the results deduced from firing.

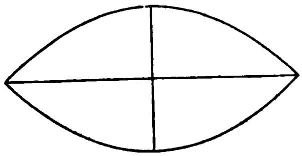


FIG. 11.

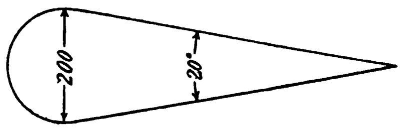



FIG. 12. 1370

In the beginning of this article we referred to the influence exercised by the body of the projectile upon the resistance encountered by the projectile. We will give some data in this connection.

Renard and Eiffel found for a sphere $F=.158$ and $.17$ respectively, values which represent nearly one-half those corresponding to a hemisphere.

For a fusiform body which is symmetrical and has a parabolic meridian, length two and three times the maximum diameter (Fig. 11), Renard found $F=.073$ and $F=.032$. For a sphero-conical body (Fig. 12) formed by a hemisphere of 20 cm. diameter and a cone of 20° angle at the apex, Eiffel found $F=.153$ and $F=.083$, according to whether the cone or the hemisphere was foremost.

These experiments, largely confirmed by all others, which have served to determine the form of dirigibles, in our country too [Italy], show the very great advantage which may be derived from tapering the rear part of the moving body; this is true at least for the relatively small velocities used in the experiments. When we pass to ballistic velocities, particularly to the very high velocities nowadays employed, the influence of the form of the rear part must certainly diminish; in the latter case it has even been stated that the advantage must disappear completely.

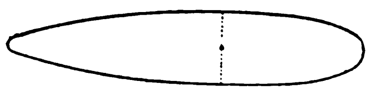


FIG. 13. 1371

We believe that the question cannot be discussed with sufficient exactness, because we lack safe and accurate data concerning the manner in which the air acts on the rear part of the projectile. Certain data, however, would lead to the assumption that for projectiles also the resistance of the air diminishes when the rear part is tapered.

Piobert indicated (about 1835), as a form of least resistance for projectiles, that of an ovoid five calibers long with the front part more rounded than the rear and the maximum section located $\frac{2}{5}$ of the distance from the front

end (Fig. 13). We do not know upon what tests Piobert based his statement; his projectile was never tried.

Projectiles with bodies tapering towards the base have been proposed at different times as follows: by Dreyse (1840) for rifles (Fig. 14); by Timmerhans and by Schenckle (about 1860) for guns (Fig. 15). In these cases,

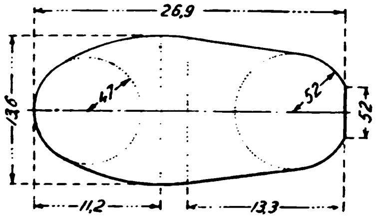



FIG. 14. 1372

however, the special form seems not to have had for its object the diminution of the resistance of the air, and we are not aware whether such advantage was realized. Of the Whitworth projectile (about 1860), which had the rear part a truncated cone (Fig. 16), the special qualities were noted. In a series of tests made at the camp of Châlons from 1863 to 1867 with the Whitworth projectile, at ranges of 6000 meters, an increase of about 700 meters in range was obtained as compared with projectiles having a cylinderical body with a

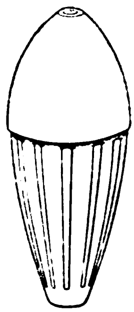


FIG. 15. 1373

plane base.* Silvestre, who first proposed the use of the coefficient of form, assigned to the Whitworth projectile a coefficient equal to $\frac{6}{7}$ of that corresponding to projectiles of the same form but having a cylindrical body terminated by a plane base.† If, in view of this advantage, projectiles of this type have not yet been adopted in service, it is due to the irregularities met with in firing.

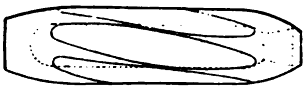


FIG. 16. 1374

The idea of tapering the body of the projectile towards the base has recently been taken up again by Hebler and also in France with the rifle ball

* *Revue d' Artillerie*, vol. LVII, p. 430.

† *Revue d'Artillerie*, vol. LVIII, p. 243.

"D" (Fig. 17). It is to be noted that the coefficient of form derived from the range table for the French cavalry carbine (the range table for the rifle has not been published) is nearly equal to $\frac{6}{7}$ the coefficients found for the fusiform bullets having the body cylindrical; so that it would appear that even with a high velocity (637 meters) a projectile with a body tapering towards the base gives a sensible diminution of the resistance of the air. This result by itself does not constitute an absolute proof; but it is an index which we must endeavor to confirm.

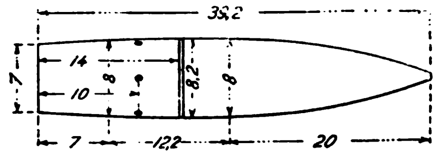



FIG. 17. 1375

As proposed at the beginning of this article, we have presented here briefly the theoretical and practical data which we have been able to collect on the value which may be attributed *a priori* to the coefficient of form. The reader will have observed how little we know on the subject and how much, in what is considered known, is supposititious, unreliable, and contradictory. And yet the value of this coefficient has considerable theoretical and practical importance.* We express the wish that the lack of knowledge on the subject may give motive and impulse for undertaking studies which, with the cooperation of theory and experiment, may give a large harvest of reliable results.—*Rivista di Artiglieria e Genio.*

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## COAST DEFENSE IN FRANCE

The evolution of coast defense in France has recently passed through several stages of executive order, criticism, and legislation; and, though necessarily some of those stages are now obsolete, yet, because of their interest, all are presented in the following reprints.

It will, of course, be recognized that the reprints are presented wholly without indorsement, either of the organizations proposed or adopted or of the opinions expressed.

To the reprints relating to the evolution of French coast defense in the matter of general organization is added one that treats of the arrangements made for maintenance of materiel.—*The Editor.*

### I

### CHANGES IN THE ORGANIZATION OF THE COAST DEFENSES

In September, 1912, *The Navy* printed a description of the organization of the French coast defenses,† based on the armaments of the coast fortifications by the war department. It is evident, however, that army officers' efficiency is limited in determining not only the nationality of ships in sight, but also the course they are steering, their combat formation, and, what is most important of all, their probable intentions. On the occasion of the annual maneuvers, army artillerymen have several times fired upon French ships. Vigilance in time of hostilities would prove all the more difficult

*It suffices to observe that in direct fire, two different projectiles fired with the same muzzle velocity will have the same residual velocity at ranges proportional to their respective reduced ballistic coefficients; that is, for the same caliber and weight, the remaining velocities will be inversely proportional to the coefficients of form.

†See JOURNAL U. S. ARTILLERY, November-December, 1912, p. 375.

because the adversary would disguise his vessels,—for example, by increasing the number of smokestacks and turrets with conveniently disposed platings, thereby making their known silhouettes unrecognizable. For this reason, in 1904, the navy was placed in command of the coast fortifications—but only in war time. This was not sufficient.

Although the navy seems naturally designed to man the guns on shore against a moving target at sea, the war department for more than a century past has had the monopoly of those operations, and so far has opposed any change, jealously maintaining its prerogatives and eluding every advance. Meanwhile, this anomalous situation was contended against; and now, after long parleys between the war and navy departments, by a decree of April 3 [March 18?], 1913, the coast commanders have been given charge of the batteries and defenses of the coast fortifications, in war time as well as in time of peace. Thus the War Department, yielding some of its pretensions, cedes to the navy (in the coast fortifications) the defense against the enemy "afloat."

But, outside the navy yards, the cooperation of the two departments demands a reorganization and definite regulations, instead of the present intricate arrangement.

Circumstances favor this evolution for the better. In the face of the German military increase, France, under the pressure of public opinion, is trying to line up all her resources in men, besides the three years' service which Parliament very likely will not fail to vote.

The "*inscrits maritimus*" serve their time exclusively on board ship, and the number of *incsrits* in the reserve is calculated to be eighty thousand. Now, at the moment of mobilization, the navy can absorb only forty thousand men, and forty thousand more remain available. The latter group would have its natural employment in the defense of the coasts, the men composing it replacing the soldiers detached from the forts, to man the guns and guard the works. That arrangement was proposed fifteen years ago, but, for some reason, was not carried out. It is now revived in the new law on the recruitment of seamen which is soon to be debated, for the problem of effective forces presses for a prompt solution.—*The Navy.*

## II

## Responsibilities of the War and Navy Departments as Fixed by the Executive Order of March 18, 1913

*Paris, March 18, 1913.*

*Report to the President of the French Republic from the Minister of War*

Mr. President:

The distribution between officials of the war and navy departments of responsibility in time of war for the service of security and for the defense of the coasts, is fixed by the regulations of September 18, 1904.

Those regulations are no longer in harmony with the principles which it seems ought to govern organization for coast defense.

The concentration of means which is required to-day for coast defense: the extension to the coast line which has fallen to the agencies for security and information at sea; and, finally, the conditions of employment of modern fleets, render it imperative that the regulations of 1904 be revised, and make it desirable that the functions of the naval and military authorities charged with the defense of the coast be modified.

It is, moreover, desirable that each of those authorities exercise in time of peace, so far as may be practicable, the functions which will devolve upon him in time of war. For instance, if the duty of the naval prefect in what concerns the elements afloat and the agencies of security and information which fall under his authority should remain unaffected, the same would not be true as regards his duty in what concerns the shore elements that in fortified places, other than his headquarters, assist in defense against a hostile fleet. Compelled, in his capacity as commanding officer of a fortified point, to reside at his headquarters, the naval prefect could not discharge this duty in an efficient manner; he should not, therefore, keep either the office or the responsibility.

The direction of this defense should be given in each fortified place to the commanding officer of that place, aided by a naval officer performing the duty of commandant of the sea front. It is the duty of this latter, by means of the sea and land forces placed at his disposal, to repulse naval attacks against the place.

It is indispensable that the commandant of the sea front be able in time of peace to prepare himself for the work which would fall to him in case of an attack, and this requires his permanent presence at the place whose defense he is in part charged with. It is also important that this officer should at all times exercise a certain authority over those elements which in case of mobilization he would be called upon to make use of.

The extent of authority over the coast artillery which belongs to him should be very clearly defined in the regulations, and should be the subject of special instructions. The extent of this authority results from the exclusively tactical rôle which falls to the commandant of the sea front in making use of the elements which the commanding officer places at his disposal.

But, if the naval prefects in the face of the enemy no longer have any other responsibility than the defense of their headquarters, the obligation nevertheless remains for them to make preparation for defense, *from a naval point of view*, of the other places of their district, and to give those places, if necessary, the assistance of the floating elements of which they have control.

It is important, therefore, that they be kept informed as to the preparations for defense of the sea front of those places; and it is with this object that they will continue to exercise an advisory control over all the projects of the local joint commissions of the ports of their districts.

In order to carry into effect these new arrangements, by which, moreover, is emphasized the obligation to cooperation which rests alike upon the war and navy departments, I have the honor to recommend that you sign the executive order herewith. This order promulgates as regulations measures determined upon after consultation with the Secretary of the Navy.

Very respectfully,

(Sgd.) Eug. Etienne.

*Executive Order*

The President of the French Rebublic,

Having considered Art. 13 of Section I of the law of July 10, 1791, relative to the preservation of fortified towns and military posts, and the orders of January 3, 1843, which establish the responsibility of the minister of war for the defense of the land and sea frontiers;

Having considered the executive order of September 18, 1904, approving the regulations of September 18, 1901, relative to the defense of the seacoast;

Having considered the executive order of March 15, 1912, modifying the regulations of September 18, 1904, relative to the defense of the sea coast;

Having considered the executive order of March 29, 1901, relative to the responsibility of naval prefects as commanding officers of military ports, headquarters of naval districts;

On the recommendation of the minister of war made after consultation with the minister of marine,

Orders:

Art. 1. The following regulation, which abrogates and supersedes the regulation of September 18, 1904, fixing the distribution, in time of war, of responsibility attacing to officials of the war and navy departments for the service of security and the defense of the coasts, is approved and will be carried into effect.

Art. 2. The secretaries of war and navy are charged, each in his own department, with carrying this executive order into effect.

(Sgd.) R. Poincaré

By the President of the Republic:

(Sgd.) Eug. Etienne,
Secretary of War.

(Sgd.) Pierre Baudin,
Secretary of the Navy.

*Regulations*

*Paris, March 18, 1913*

## Chapter I

### GENERAL DISTRIBUTION OF RESPONSIBILITY

Art. 1. The secretary of war is charged with the defense of the land and the sea frontiers. To this end, he has placed at his disposal, besides the means pertaining to his own department, the means belonging to the navy department.

Art. 2. For the purpose of fixing the responsibility for the coast line of officials of the war and navy departments, coast defense is divided into:

a. Defense of fortified points of the coast line;

b. Defense of the coast line outside of fortified points.

Art. 3. The defense of the fortified points of the coast line is itself divided into two parts:

a. Defense against an enemy afloat;

b. Defense against an enemy in the act of landing or already landed.

The commanding officer of the fortified point is responsible for both.

The first is directed, under the supervision of the commanding officer, by a naval officer.

The second is confided to officers of the army.

Art. 4. The defense of the coast line situated outside of fortified places is in all cases confided to persons under the authority of the war department.

## Chapter II

### IN TIME OF WAR

### §1. *Defense of fortified points of the coast line*

Art. 5. The commanding officer of each fortified point is responsible for its defense.

naval district. In the exercise of his duties as commanding officer he is under the authority of the secretary of war. He is charged with the service of security and information of the coast line of his district and the service of lighthouses and buoys is under his control.

Art. 6. The naval officer who in each fortified place is charged with its defense against an enemy afloat is given the title of commandant of the sea front.

All the naval means of defense are under his authority, and, from the tactical point of view only, the coast artillery.

Art. 7. To enable him to carry out his duties, the commandant of the sea front of each place has under his authority:

a. The floating elements belonging to the navy or requisitioned by the navy and placed at the disposal of the commandant of the sea front by the navy department;

b. The means of reconnaissance and of fixed defense belonging to the navy department;

c. The coast artillery, from the point of view of its tactical use;

d. Such portions of the garrison as the commanding officer shall deem it expedient temporarily to place at his disposal for the security of the works on the sea front;

e. The personnel and matériel belonging to any department other than the war department which, in time of war, is placed at the disposal of the navy for defense against an enemy afloat.

Art. 8. The employment of the means enumerated in a and e of Art. 7 remain subject to the authority of the navy department, and orders relative to them may be given directly by the naval prefect to the commandant of the sea front. In ports other than the prefect's headquarters, the commandant of the sea front reports to the commanding officer any orders thus received.

Besides this, the navy, in its own service of security and information seawards, has control, along the coast line, of the following:

a. Intelligence offices;

b. Electric semaphore stations and radio stations belonging to the navy or placed at its disposal in time of war.

All of these agencies, even those located in a port other than a military port, are directly subject to the authority of the naval prefect. All information concerning the defense of a place gathered by the agencies located there are communicated immediately and directly to the commanding officer through the commandant of the sea front.

Art. 9. In cases in which their responsibility makes it possible, commanding officers accede to requests made to them by naval prefects and commanders of naval forces for any cooperation or help which their command can render the fleet.

Likewise, in case of an attack on a fortified place, all floating elements, even those that do not belong to the place which chance to be at hand and which have no other express mission to execute, should assist in its defense.

§2. *Defense of the coast line outside of fortified points.*

Art. 10. Generals commanding army corps districts on the coast are charged with defending them against an enemy landing or already landed. To the full extent of the mobile elements of defense under their control,

they are to cooperate in all efforts the object of which is to prevent an enemy from using anchorages situated outside fortified points of the coast.

As an exception to this rule the 2nd army corps district is not considered a coast district. The Abbeville subdivision is in time of war attached to the 1st district for purposes of coast defense.

Art. 11. For this purpose, generals commanding army corps districts on the coast make use of all the mobile troops belonging to their territory or temporarily placed under their orders.

Their authority over fortified points of the coast, from the moment an enemy commences his landing operations, is defined in Arts. 150 and 151 of the executive order on the service of fortifications.

Art. 12. Outside of fortified points, all elements or troops belonging either to the war or the navy department, remain subject exclusively to their respective departments.

The war department is, however, charged with guarding all important points on the coast which it is necessary to protect, but it does not interfere with the employment of elements which pertain to other departments. This guard duty is, as a rule, organized by subdivisions of army corps districts and is performed under the supervision of the commander of the subdivision. So also is the coast guard service, performed by the customhouse personnel, under his supervision.

Art. 13. The department of war and of the navy has each its own intelligence service. Anything affecting the defense which is learned by one is transmitted to the other by the most rapid means possible.

## Chapter III

### IN TIME OF PEACE

Art. 14. Naval prefects and commandants of sea fronts receive in time of peace letters of command from the secretary of war, on the one hand, and the secretary of the navy, on the other, which define their authority over the elements belonging to each department.

Copies of these letters are exchanged between the respective secretaries.

These letters of command may be impersonal.

Art. 15. The naval officer who is commandant of the sea front exercises his functions in time of peace. As a rule, he resides in the fortified place. In this case, he has in time of peace authority over the elements enumerated in Art. 7. However, in what concerns the coast artillery, this authority is only tactical and is exercised only on occassions of special exercises in which both departments take part. The commandant of the sea front does not interfere in matters affecting the internal discipline of the batteries.

The commandants of sea fronts are under the immediate authority of the naval prefect in all that concerns the floating elements and the organization of the fixed defenses which belong to the navy. In the tactical use of the elements named in paragraphs b, c, and d of Art. 7, they are directly under the orders of the commanding officer.

Commandants of sea fronts who do not reside in time of peace in the fortified places to which they are assigned, are called upon at certain periods to inspect those portions of the fortified place over which their authority would extend in time of war and to study the means placed at their disposal. They take part in the special exercises mentioned above.

Art. 16. The secretaries of war and of the navy keep each other in-

formed of all changes made in the assignment of elements or troops of their respective departments employed in fortified ports, whether these changes affect a part only or all of the elements or troops.

Art. 17. Naval prefects are informed of the plans of defense of the fortified places of their district. They submit to commanders of army corps any recommendations they may have to make concerning the sea fronts.

### Chapter IV

#### SPECIAL PROVISIONS FOR CORSICA, ALGERIA, AND TUNIS

Art. 18. The service of security and the defense of the coast of Corsica and of the coast of Algeria and Tunis devolve in time of war respectively upon the governor of Corsica and the commanding general of the 19th army corps.

In Corsica, the naval commandant exercises at all times, under the direction of the governor, the functions of commandant of the sea front of Ajaccio and has the authority of a naval prefect, in so far as concerns the use on the island of means pertaining to the navy department.

In Algeria and in Tunis, the naval commandants have, under the supervision of the commanding general of the 19th army corps, the functions specified in these regulations for naval prefects, in all that concerns the use of the floating defenses and the naval intelligence service.

For the defenses of Algiers, of Oran, and of Bizerta, a naval officer, subject to the orders of the commanding officer, always exercises the authority of commandant of the sea front.

In Corsica, in Algeria, and in Tunis, the use of the floating defenses rests with the secretary of the navy, who accordingly communicates his orders directly to the naval commandants. The latter report them to the governor of the island or to the general commanding the 19th army corps.

The semaphore stations remain under the technical management of the navy, and are to give precedence in transmission to communications relative to naval operations.

The Bizerta arsenal, the dry docks, workshops, and magazines specially established for the needs of the fleet, are under the exclusive orders of the naval commandants.

(Sgd.) Eug. Etienne, Secretary of War

(Sgd.) Pierre Baudin, Secretary of the Navy

—*Bulletin Officiel du Ministère de la Guerre.*

## III

## A Criticism of the Executive Order of March 18, 1913

By Senator Lucien Cornet, Secretary of the Military Committee

Is the end and aim in matters of military organization so to befog common sense that it may be absolutely unable to detect reasons or to understand ways and means? If so, it must be admitted that the executive order of March 18, 1913, relative to coast defense, is indeed a masterpiece.

It would seem that the two departments, war and navy, which prepared this order, had as their sole object, not defense of the coasts, but division of the work—forgetting that that was an excellent way to divide the responsibility, which is the same thing as eliminating it; and that cannot be done without some risk to the country.

It is impossible to imagine a more complete entanglement of authority: the several jurisdictions overlap one another in an utterly chaotic manner. We have naval prefects who, being commanding officers of defenses, are, in their capacity as such, under the war department; and a war department which, though it controls the armament, yet must appeal to the other—we were about to say rival—department to learn where it is to strike its blow. Unhappy warrior, who is blind and deaf! The best thing for him and for those whom it is his duty to defend, is a continuance of peace, which benevolently renders him as little serious as the *opéra bouffe* general who spent his time asking where the enemy was.

The naval officer, commandant of the sea front, has command of "such portions of the garrison as the commanding officer *shall deem it expedient* temporarily to place at his disposal." (Art. 7, e.) If the commanding officer determines the expediency, what does the naval officer do in the matter? "*In cases in which their responsibility makes it possible*, commanding officers accede to requests made to them by naval prefects." (Art. 9.)

Generals commanding army corps districts on the coast "cooperate in all efforts the object of which is to prevent an enemy from using anchorages situated outside fortified points of the coast." (Art. 10.) Upon whom and upon what may the naval prefects rely? That is a question which must disturb them not a little.

"Outside of fortified points, all elements or troops belonging either to the war or the navy departments, remain subject exclusively to their respective departments." (Art. 12.) That is to say, a naval prefect would not have authority to use a corporal's squad in case a signal station informed him of an unexpected landing at a point on the coast some distance from a fortified point. That is disquieting enough; but there is a clause which is more disquieting: "The war department is, however, charged with guarding all important points on the coast *which it is necessary to protect*, but it does not interfere with the employment of elements which pertain to other departments." Can anything more confusing be imagined? Zeal for the sanctity of "departmental" jurisdiction seems to stifle thought of national defense. Are there anywhere on the coast line points *which it is not necessary to protect?* We are anxious to know where they are. And is it reasonable that a man responsible for the defense of a place should be prohibited from using certain means to its defense? That is tantamount to confessing that things will go amiss, that one knows it, and that one is resigned to one's fate.

And what will render conflict between the two departments not only possible, but probable, is that, under the provisions of Art. 13 "the department of war and of the navy has each its own intelligence service." For one to learn of a fact several hours after the other, is all that will be needed to cause it peremptorily to refuse to take part in measures which it believes void of usefulness. It is very certain that the two departments will communicate their "information" to each other; but "information" is capable of different interpretations. Officers of the army and officers of the navy, both, will have a very human tendency to believe only such "information" as reaches them through sources known to themselves. In short, there have been deliberately introduced occasions for discussions and controversies where it is important that they be avoided at any price.

It is not a matter of questioning in the least the ardent patriotism of the two services: in fact, it is their very patriotic zeal which will impel army officers and navy officers to see their duty from different points of view.

Instances have occurred, and one not long ago. No one has forgotten what happened in the Bight of Benin because of dual command. In Benin, as a consequence, command has very rightly been given to the army, for the danger is on land. And in coast defense, without concern for a false pride which is wholly lacking in justification or excuse, command must be entrusted to the man familiar with things of the sea, for the danger is on the sea. And unity of command is essential to unity of responsibility. One should be supreme in the domain in which one can get along without others—not entirely, perhaps; but more than others could get along without him.

That being so, here is what the very nature of the situation indicates. Beyond the mean range of the coast guns, the service of security is intrusted to fleet commanders and to commanding officers of floating units. It goes without saying that this service has a strategy of its own, and that those responsible for it must be entirely independent in the use they make of the information that comes to them from all sources. It may be more expedient to go to meet an approaching hostile fleet than to cooperate with the coast defense forces in repelling a landing of little importance.

As soon as a naval enemy approaches the coast within gun range, it is the naval prefect who is apprised of that fact through his signal stations; and it is he, he alone, whose duty it is to keep the enemy at a distance or to destroy him. He must have authority to employ, in time of war, all forces that, in their respective spheres, will aid in keeping the enemy at 300 yards from the coast; that is to say, will prevent his landing. He alone has control of the means of reconnaissance, because he alone knows how to use them. He alone is capable of distinguishing between a feint and a real attack. He has possession of the information gathered; without losing a minute, he can interpret it and put it to use. How can the commander of an army corps be expected to make use of the aids to navigation—lights by night and buoys by day—for the purpose of leading a bewildered enemy over a line of mines?

The naval prefect, moreover, in fulfilling his mission, has no need to meddle in cavalry tactics in order to prevent the enemy's coming within rifle range. His sole duty is to warn the commander of the army corps district or subdivision of the place where the enemy seems to be concentrating his effort and contemplating a landing, of the place also to which he is repairing in person, because the danger is there. But all the guns which may be in the vicinity should be entirely at his disposal.

If the enemy, overcoming the defensive efforts of the naval prefect, succeeds in passing the 300-yard line, the naval authority turns the matter over to the military authority, and the naval prefect has nothing more to do but place himself under the orders of the commander of the land forces, even though that commander should be only a major. The gun, from this time on, as in the field, can be only an aid to the rifle. It is now a question of a hand-to-hand fight, for which the soldier is better prepared than the sailor. It is in order for the infantryman to prevent the landing by all means at hand, without regard to the department to which those means pertain. It is his duty to force the assailant back to sea, to drive him out of the rifle zone on to the high seas, where he will again be under the jurisdiction of the naval prefect. Sailors are wont to say, "when every one stands by his own station, the ship is safe." Now, everyone is standing by his own station in coast defense, when the infantryman does not interfere with naval matters, of which he knows nothing; and when the sailor has exclusive

control of all available forces as long as the enemy is in the zone with which the sailor is familiar, and which he alone can defend.

The thing to be borne in mind is, that it is not a question of deciding between interests, prerogatives, powers, and jurisdictions, but a question of concentrating command in zones in each of which the only responsibility shall be the public safety.—*La France Militaire.*

IV

### Manned by Sailors

It has been decided that from April, 1914, the coast artillery shall be manned by sailors, and the army personnel will be transferred to the eastern frontier.—*The Army Review.*

V

### Regulations for the Organization and Operation of Working Parties Charged with the Maintenance of Coast Artillery Materiel

*Paris, April 5, 1913.*

#### I. DUTY OF COAST ARTILLERY WORKING PARTIES

In the coast artillery arsenals are working parties, called *équipes côtières,* which are under the orders of an officer of the arsenal and which periodically make the circuit of the fortifications for the purpose of repairs to and maintenance of the coast artillery matériel.

When practicable, the officer should be one who has taken the course of instruction arranged by the coast artillery committee. He is primarily charged with the annual inspection of the coast artillery matériel.

The working parties have a two-fold duty:

1. *Usual duty.*—They insure the constant maintenance of the matériel in serviceable condition, dismounting parts when necessary, but only when necessary, and making such repairs as can be made on the spot with the tools at hand. They attend to assembling and adjusting spare parts and parts of modified types that are being substituted for obsolete patterns. But in no case are they required themselves to manufacture parts of matériel.

They are present at target practice, not only in order to report upon the functioning of the various parts, but also to be themselves informed as to the different accidents and to remedy them at once, if occasion arise.

2. *Occasional duty.*—Besides the work which has just been enumerated, the working parties attend to:

a. The assembling and dismounting of matériel incident to work of arming and disarming;

b. The assembling of the iron parts of artillery mounts;

c. The making of modifications and alterations of matériel which are to be done on the spot. For these tasks they may be given special tools.

*In Time of War*

In time of war, coast artillery working parties continue to work as in time of peace. The officers, the foremen, and their workmen are, therefore, given a mobilization assignment which keeps them on this special duty.*

* In the makeup of the working parties there are not to be, then, either officers or men belonging to mobilized combatant units. These units are to be called upon only to furnish for the working parties in the fortifications where they themselves are, the helpers provided for in paragraph II.

The number and the distribution of the coast artillery working parties in the arsenals and branch arsenals, are fixed by the Secretary according to circumstances.

## II. COMPOSITION OF THE WORKING PARTIES

Each working party includes a foreman, an assistant foreman, workmen, and helpers.*

The foreman is, as a rule, an *ouvrier d'état en fer* (a master machinist), or a *gardien de batterie* (an ordnance sergeant), or a *maréchal des logis chef ouvrier* (a machinist sergeant), or a *maréchal des logis de section d'ouvriers* (a sergeant of the service corps), reenlisted or remaining with the colors after his term of service.

The assistant foreman is, as a rule, a *maréchal des logis de section d'ouvriers* (a sergeant of the service corps) or a *brigadier de section d'ouvriers* (a corporal of the service corps), reenlisted or remaining with the colors after his term of service.

(Occasionally, and only in an emergency, the duties of foreman may be entrusted to a *maréchal des logis mécanicien du régiment*—a regimental machinist sergeant—who has taken the special course of instruction.)

They must be machinists, must besides have had a special course of instruction, and must at the end of that course have received a certificate of qualification for the duties of foreman. The assistant foreman must be capable of taking the foreman's place, in case of absence, and of eventually succeeding him upon his detachment.

It is important that neither the foreman nor the assistant be transferred unless a successor is definitely assured; that is, unless there is in the arsenal another non-commissioned officer who is the holder of a certificate of qualification.

The same considerations govern transfers of officers in charge of working parties.

Commandants of arsenals should keep those considerations in mind when designating individuals to take the course of instruction.

The ordinary members of the working party are, as a rule, civilians chosen from amongst the most skilful machinists, fitters, etc., employed by the arsenal, or—but only in case of a lack of civilians—machinists of the service corps detachment assigned to the establishment.

Their number is usually determined as follows:

For a group of 40 (or fewer) pieces of large caliber, 2 machinists;

For a group of from 40 to 80 pieces of large caliber, 3 machinists;

For a group of 80 (or more) pieces of large caliber, 4 machinists.

According to the character of the repairs to be made, there may be, in addition to the machinists, a carpenter, a mason, a painter, etc.

The helpers are privates (they may or may not be mechanics) placed under the orders of the foreman and intended to reinforce the working party in the performance of mechanical maneuvers incident to inspecting matériel or to making alterations.

In order to keep travelling expenses at a minimum, the helpers may be taken from different organizations in the vicinity of the fortifications to be

* It is not required that the foreman and his assistant shall both take part in all the work of the party. Generally, only one of them will supervise the work, but the other ought to keep himself sufficiently in touch with it to be able eventually to assume direction of it especially in case it should become necessary to divide the party.

visited. On the other hand, the regular members of the party, the machinists, are unchanged during the working party's circuit.

### III. ROUTINE OF THE WORKING PARTY

Besides certain urgent repairs called for by extraordinary accidents and requiring immediate attention, the coast artillery working parties should visit *twice each year* the fortifications the matériel of which is used for purposes of instruction or target practice. One of these circuits is made, as a rule, at the end of winter, and the other after target practice or after the close of the annual period of instruction. Of the other fortifications, the working parties make but one circuit a year—preferably at the end of winter. However, commandants of arsenals may cause more frequent visits to be made to batteries where local circumstances render such action necessary.

The officer in charge of working parties determines the nature and extent of the work. A preliminary estimate of the work is furnished him in reports of accidents to matériel rendered by ordnance sergeants as soon as the accidents occur; and, in the case of instruments, by remarks made on reports of inspection. In order to supplement this information, he goes to the fortifications, has the foreman inspect the matériel in his presence and determines at that time, as a rule, the repairs, the cleaning, etc., which should be undertaken.

If occasion arise, he calls for helpers for the mechanical maneuvers judged necessary, as well as for the special workmen, painters, carpenters, or masons whose assistance is temporarily needed; also, he makes out the requisitions for articles to be manufactured at the arsenal shops.*

Any part thus manufactured must conform strictly to the tables of specifications.

In all that concerns maintenance, the officer must not lose sight of the fact that the ordnance sergeants are responsible for keeping their fortifications in serviceable condition.

While the work of a party is going on, the officer verifies by frequent inspections the carrying out of his instructions, and he makes such changes in them as he recognizes to be expedient, after the dismounting of parts required in the performance of the work has taken place.

When a working party is about to leave a fortification, he inspects the repairs made and makes sure that the matériel has been put back into condition.

In the case of instruments, the inspection of repairs must be made by the officer who made the annual inspection.

### IV. EQUIPMENT

Each working party is provided with a set of tools which, as a rule, in the case of a party comprising two machinists, contains the articles indicated in the two lists shown in the table appended to this memorandum.

The components of the set of tools enumerated in the first list may, if necessary, be modified at the arsenals for the purpose of conforming it, in the case of the tools proper, to the strength of the party, and, in the case of the miscellaneous articles, to the model of the pieces mounted in the fortifications to be visited.

* If the arsenal shops are not prepared to fill the requisitions, the parts to be manufactured are requisitioned by the arsenal from the war department.

If the arsenals have not an adequate supply of tools and miscellaneous articles, they make requisition upon the War Department (3d Division, 2d Bureau) for the tools needed to supply the deficiency.

The equipment of list No. 1 is locked in a chest for which the foreman is responsible.

The equipment of list No. 2, which includes such objects as cannot be put in the chest, is placed at the call of the foreman by the arsenals.

For certain kinds of work these articles may be supplemented by the addition of a special outfit (electric set, boring and milling machines, etc.).

### V. EDUCATION OF FOREMEN

Foremen and their assistants must hold certificates of qualification for the duty, issued by the coast artillery committee at the end of the course of instruction.

This course is held for each group of fortifications every two years, as a rule, or more frequently if the needs of personnel require.

It is held alternately: at Toulon, in even numbered years, for the officers and the candidates for position of foreman in the arsenals of Bastia, Marseilles, Nice, Toulon, Algiers, Constantine, and Oran; at Cherbourg, in odd numbered years, for the officers and the candidates for position of foreman in the arsenals of Bizerte, Dunkerque, Le Havre, Cherbourg, Brest, Lorient, and La Rochelle.

The session at each place where the course is given, is four weeks—in September and October at Toulon, and in May and June at Cherbourg.

The corps of instructors comprises: two officers of the coast artillery committee; one machinist staff officer; one foreman of the arsenal where the course is held. Besides, a certain number of machinists and men on special duty are, in each place of instruction, placed at the call of the instructors for use in mechanical maneuvers.

The candidates for the positions of foreman and assistant foreman of working parties are designated by the commandants of arsenals from among the arsenal foremen, noncommissioned officers of the service corps detachment, and ordnance sergeants who still have a considerable time to serve in their present positions: the candidates must be familiar with the coast artillery matériel and have the professional qualification needed for successfully directing the machinists placed under them.

Recommendations as to the course of instruction, prepared in conformity with the requirements of paragraph 11 of the current order, must reach the War Department (3d Division, Office of the Chief) by the first of July for the Toulon course, and by the first of March for the Cherbourg course.

### VI. UPKEEP OF MATERIEL

Maintenance of matériel devolves upon the ordnance sergeant, assisted, if need be, by an enlisted man or a laborer placed under his orders.

To ungarrisoned fortifications, where the ordnance sergeant could not accomplish some tasks, such as the monthly pulling from battery of certain pieces, the commandant of the arsenal may cause to be sent periodically the special fatigue parties which are furnished by the nearest garrisons for execution of mechanical maneuvers.

In such cases, the duties of working parties are generally limited to detailed inspection of miscellaneous articles, to verification of adjustment of

parts, to cleaning which requires the dismounting of complicated mechanism, to repairs, and to alterations of matériel.

Commandants of arsenals must exercise constant supervision over the state of preservation of matériel. They cause the officers under them to make a detailed inspection each month, for the purpose of ascertaining whether the ordnance sergeants are themselves attending to everything necessary for keeping the matériel in serviceable condition, or are depending upon the working parties. They cause the results of these inspections and the condition of the matériel and emplacements to be noted in the semi-annual reports on coast artillery matériel and supplies.

### Components of the Set of Tools Allowed Coast Artillery Working Parties

List No. 1.

| Name of Article. | | | Number. |
|---|---|---|---|
| Vise, field portable | | | 1 |
| " 6.5 to 11 lbs. | | | 1 |
| " locksmith's standing | | | 1 |
| " hand | | | 2 |
| Punching machines | double socket | large, 1.99-in. diameter | 1 |
| | | medium, .98-in. to 1.18-in. diameter | 1 |
| | for various powers | | 1 |
| Pliers | flat-nose | | 1 |
| | cutting | | 1 |
| | electrician's | | 1 |
| Hammers | sledge | | 1 |
| | hand | | 2 |
| | riveting | | 1 |
| Mallet, copper | | | 1 |
| Smiths' tongs | straight | | 2 |
| | bolt | | 2 |
| Chisels, locksmith's | | | 6 |
| Chisels, locksmith's, mortising | | | 6 |
| Die stocks | medium | | 1 |
| | small | | 1 |
| | trowel | | 1 |
| Dies for stock, sets | | | 2 |
| Taps, machinist's, sets | | | 3 |
| Soldering irons | ordinary | | 2 |
| | special | | 1 |
| Files, bastard, 14-inch | flat, square | | 1 |
| | flat, taper | | 1 |
| | half round | | 1 |
| | square | | 1 |
| | round | | 1 |
| Files, bastard, 10-inch | flat, square | | 1 |
| | flat, taper | | 1 |
| | half round | | 1 |
| | square | | 1 |
| | three-cornered | | 1 |

| Name of Article. | | Number. |
|---|---|---|
| Files, smooth and second cut, 6-inch and 10-inch | flat, square | 2 |
| | flat, taper | 2 |
| | half round | 2 |
| | round | 2 |
| | square | 2 |
| | three cornered | 2 |
| Files, straw-packed, 10-inch to 14-inch | flat, taper | 2 |
| | flat, square | 2 |
| | half-round | 2 |
| Handles, hammer | sledge | 1 |
| | hand | 1 |
| | riveting | 2 |
| Handles, file | | 10 |
| Compasses, machinist's | | 1 |
| Calipers | hermaphrodite | 1 |
| | vernier to 1/10 | 1 |
| Quadrant, gunner's, model 1886 | | 1 |
| Scriber, machinist's | | 1 |
| Scriber, adjustable sleeve | | 1 |
| Tap-wrench, medium | | 1 |
| Tap-wrench, small | | 1 |
| Figures, 1/10-inch, set | | 1 |
| Figures, 16/100-inch, set | | 1 |
| Figures, 24/100-inch, set | | 1 |
| Letters, 16/100-inch, set | | 1 |
| Letters, 24/100-inch, set | | 1 |
| Rule, folding, brass | | 1 |
| Nippers, beveled | | 1 |
| Reamer, taper, 16/100 to 7/10 | | 1 |
| Drills, twist, 16/100 to 79/100 | | 1 |
| Drills, ratchet | medium | 1 |
| | small | 1 |
| | Puteaux | 1 |
| Straight-edge, steel | | 1 |
| Liners, steel, set of: .062, .031, .016, .008-inch | | 1 |
| Drifts, pin bolt, set: .039 to .39-inch | | 1 |
| Saw, hand, ordinary | | 1 |
| Saw, hack | | 1 |
| Blades, hack saw | | 6 |
| Assortment of bolts, rivets, and pins pertaining to the matériel cared for by the working party | | 1 |

List No. 2.

| | |
|---|---|
| Grindstone, small, with mounting | 1 |
| Forge, portable, with anvil, block, tools, and coal | 1 |
| Jack, 20- to 30-ton* | 1 |

—*Bulletin Officiel du Ministère de la Guerre*.

* For 12.5-inch guns jacks of at least 30 tons are needed.

## THE MANUFACTURE OF ARMOR PIERCING PROJECTILES*

By General LEANDRO CUBILLO (Madrid)

Since the inauguration of the era of armored vessels by the equipment of the French frigate *Gloire*, the necessity has been imposed of designing guns of such power as to impart sufficient energy to their projectiles to enable them to break down the resistance offered by the armor. In addition, it has also been required that the material of which the projectile was made and its form should be such as to produce complete perforation of the plate. Though the material of which the armor-plates were made at the time of their first introdution would present no difficulty of attack with the means which metallurgical science at the present day places at our disposal, that was not, by any means, the case fifty years ago. It was no easy matter to pierce a plate of forged or rolled iron by direct or oblique attack with cast-iron balls or with cylindrical or ogival projectiles, even if of crucible steel, such as was then obtainable. Spherical projectiles were discarded, and cylinders with ogival points, and even cylinders with flat heads. were tried, as designed by the celebrated late Sir Joseph Whitworth, who applied his mechanical genius to the solution of many problems in metallurgy and mechanics, particularly those bearing on the construction of artillery.

The Palliser projectiles, which were the first to be used with success against armor-plates, were made of cast iron, the ogival point being cast in a metal mould, and the cylindrical portion in ordinary refractory sand. By this means it was endeavored to give extreme hardness to the material forming the point, that being the part required to perform the actual work of piercing the armor-plates. The reason why a cast iron of definite composition on being cooled rapidly becomes a brilliant white and of extreme hardness is now well known, but forty or fifty years ago the influence of silicon in counteracting the formation of white cast iron, and that of manganese and sulphur in promoting it, were entirely unknown. The melting mixtures from which the best Palliser projectiles were obtained were the result of experience on the part of foundrymen, and the various kinds of iron used in their composition were denoted by classification numbers. In a certain way the manufacture of the old Palliser projectile was similar to that of modern ones, but the operations involved in making the former were extremely short and simple. The casting of the point in a metallic mould gave to the projectile at once both its final form and the necessary thermal treatment which hardened it. In the manufacture of the projectiles of the present day the process is infinitely longer and more complicated, but in principle it is the same, and approximates the more to the Palliser process if the projectile, instead of being forged, is simply cast and subjected afterwards to thermal treatment. Certain rules based on experience contributed to good results in the manufacture of Palliser projectiles. For instance, the thickness of the metallic mould had to be equal to half the diameter of the projectile. The author is inclined to dwell on the subject on account of having himself inaugurated and taken charge of the manufacture of such projectiles for several years at the Arsenal of Trubia. When materials distinct from ordinary wrought iron began to be used in the manufacture of armor-plate the Palliser projectiles were no longer capable of piercing them, and failed completely against the Schneider plates of homogeneous steel, as well as the English compound plates, and those hardened by the Harvey or the Krupp

* Paper read before the Iron and Steel Institute at Brussels on Sept. 1, 1913.

processes. The same progress in metallurgical science which made it possible to improve the armor-plate material contributed also by degrees to the perfecting of projectiles. Advantage was taken of the property of chromium, which increases the hardening and toughening capacity of the steel in a higher degree than carbon, but without increasing the brittleness, and a certain proportion of this metal was added to the material used in the manufacture of projectiles.

For some time the Holtzer projectiles had a great reputation; these were made of chromium steel, and were greatly in demand for testing the quality of armor-plate, but when the ternary and quaternary steels came to be employed in the manufacture of the plates, the surfaces of which were cemented to a certain depth and afterwards hardened, even the chromium-steel projectiles, tempered and hardened as they were to an extraordinary degree, could not pierce the plates. Fortunately, the invention of the cap again gave the preponderating advantage to the projectile in the struggle which for fifty years has been maintained between this and the armor-plate.

When the Holtzer projectile was first introduced, about 1886, there were no plates which could withstand it in any way. During the decade 1880-1890 the compound armor-plate was in general use in England; in other countries of Europe and in America both compound and steel plates were in use, against which, as already stated, the Palliser projectiles were harmless, especially the compound plates. In the following decade, 1890-1900, the cap for projectiles came into use, and by 1896 it was generally acknowledged that it was very difficult to pierce the Harvey plates without that attachment. The United States adopted capped projectiles in 1900, and it was estimated that thereby the penetrative capacity of the projectile against Harvey plates was increased by 15 to 20 per cent, but, on the other hand, no effect was produced at angles of greater obliquity than 20 deg. from a right angle—that is, at an angle of 70 deg. with the face of the plate. Nevertheless, the testing of plates with uncapped projectiles continued up to 1904, though from 1901 the importance of the cap was daily becoming more manifest, because the points of the projectiles without that attachment broke on striking the hardened plates. The cap protected the point on the first impact, and, though the exact action has not yet been satisfactorily explained, it is certain that, whereas unprotected projectiles are warded off by the plate, those with caps easily penetrate and pierce it completely. However, it is not necessary to go further into the history of this accessory of the modern piercing projectile, and it is enough to say that its importance has become more and more recognized, and that its form and manner of attachment have changed considerably since the time of Johnson down to the most modern hollow types produced by Sir Robert Hadfield's firm, which give such excellent results when fired at an oblique angle.

*Composition and Physical Properties of the Material.*—As mentioned in the first part of the paper, the material out of which projectiles are manufactured is usually a ternary steel; sometimes a quaternary steel is used, which, in the opinion of the author, is superior to the former. The ternary steel is formed by an admixture of chromium, and a quaternary by the addition of chromium and nickel, and the proportion of the chromium in the ternary mixture, and that of chromium and nickel in the quaternary are such that, notwithstanding the relatively high percentage of carbon in the former case, the two types of steel belong to the pearlitic series—that is, their critical points, both in heating and in cooling, are above 500 deg. Cent. As

specimens of the two types of material, the chemical analyses of two ternary and one quaternary steel, as used at Trubia for the manufacture of projectiles, are given on the next page.

The examination of the chemical analyses confirms what has just been explained—that is, that both the ternary and quaternary types of steel are pearlitic. For the chromium steel it would be necessary that the percentage of the added element should be about 4 per cent, the carbon being somewhat above 0.8 per cent, in order to bring the material within the range of the martensitic steels. With regard to the chromium-nickel steel, it is necessary to reduce the chromium and carbon percentages in order to retain the steel within the pearlitic range. The great superiority of the quaternary steel over the ternary will readily be seen on examining the tensile tests. In short,

*Fig. 1.*
*HEATING & COOLING CURVES OF THE TERNARY STEEL.*
*Chromium. 2·371 per cent; Carbon. 0·819 per cent.*
*Upper Curve, Heating; Lower Curve, Cooling.*

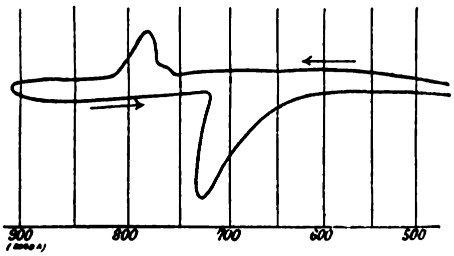
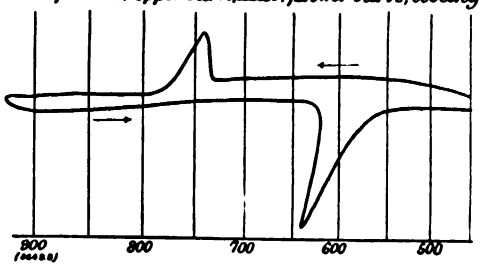



*Fig. 2.*
*HEATING & COOLING CURVES OF THE QUATERNARY STEEL*
*Chromium. 0·749 per cent; Nickel, 2·545 per cent; Carbon 0·485 per cent. Upper Curve, Heat'g; Lower Curve, Cooling*

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the elastic limit particularly and the yield-point are considerably increased, the ductility remaining the same, thus affording evidence of the great improvements due to the addition of chromium and nickel to the ordinary carbon steel.

The heating and cooling curves of the two kinds of material used in the manufacture of piercing projectiles were determined in the laboratory at Trubia, a Le Chatelier-Saladin pyrometer being used for them. The curve for the chromium steel (Fig. 1), exhibits during heating one critical point only, Ac 3, 2, 1 at 783 deg. Cent., the corresponding reverse point Ar 3, 2, 1 occurring at 730 deg. Cent.; the difference due to lag is 53 deg. Cent. If the point Ar 3, 2, 1 of this steel be compared with the point in a steel containing the same percentage of carbon, there is in the latter, accord-

FIG. 3.

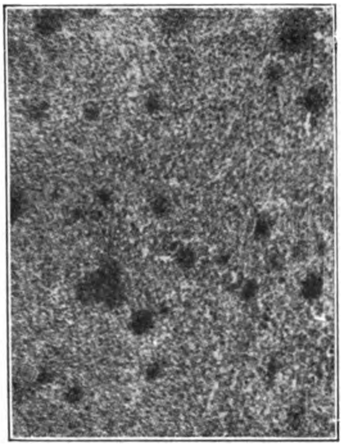


FIG. 4. 1377

FIG. 5.

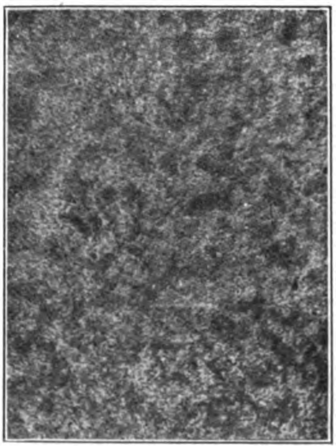


FIG. 6 1378

FIG. 3.—Specimen from a 15-centimeter chromium-nickel projectile, annealed after forging.

FIG. 4.—Specimen from a 15-centimeter chromium-nickel projectile, after hardening in oil and tempering.

FIG. 5.—Specimen from a 30.5-centimeter chromium-steel projectile, annealed after forging.

FIG. 6.—Specimen from a 30.5-centimeter chromium-steel projectile, after hardening in oil and tempering.

All samples were etched with picric acid, and magnified to 224 diameters.

ing to Carpenter and Keeling, a difference of 44 deg. Cent., which represents the amount by which the point has been lowered, due to the presence of 2.371 per cent of chromium. In the chromium-nickel steel it will be noted that the point Ac 3, 2, 1 occurs at 741 deg. Cent. (Fig. 2), whereas the corresponding point Ar 3, 2, 1 occurs at 636 deg. Cent., the difference being 105 deg. Cent., indicating an extraordinary degree of lag. In a steel with the same percentage of carbon, the corresponding point on cooling is at 777 deg. Cent., or a difference of 141 deg. Cent., which brings out very clearly the influence of the chromium and nickel, especially that of the nickel, in lowering the critical point on cooling. The determination of these critical points supplies the necessary data for fixing the temperatures at which the subsequent heat treatment should be performed in the further process of manufacture.

In Figs. 3, 4, 5, and 6, four micrographs are shown, corresponding to the ternary and quaternary steels in different states—namely, annealed after forging and quenched and tempered in oil before undergoing the final treatment. The steel annealed after forging is shown in Figs. 3 and 5, the chromium is denoted by Fig. 3, and, as the carbon percentage would lead one to expect, the microstructure contains pearlite and free ferrite. Fig. 5 is a chromium steel with a carbon percentage which approximates to that of the eutectic, and its structure is almost entirely pearlitic. Fig. 4 shows the chromium-nickel steel, and Fig. 6 the chromium steel after quenching and tempering in oil preparatory to the final treatment. The micrographic constituents are those which are characteristic of this class of carbon steels which have undergone the heat treatment alluded to.

*Process of Manufacture.*—The next question is, What are the operations necessary for the entire manufacture and finishing of a piercing projectile after the melting operation? Is forging an absolute necessity, or, on the other hand, can the projectile be cast in its approximate final form, and require no further operation to finish it than the necessary heat treatment? Theoretically it has been proved that a metal free from blow-holes derives all its physical and mechanical properties from its chemical composition and the subsequent heat treatment. If, therefore, the steel-founder can be relied upon to produce an absolutely sound metal, forging can be dispensed with, for, as the author has already pointed out in his previous paper on the manufacture and treatment of steel for guns, the principal object of forging is not so much to give the pieces their final shape as for the purpose of transforming the crystalline structure, due to casting in metal moulds, into the fine-grained and almost amorphous structure which a material with the necessary physical and chemical properties must possess. It may be mentioned that the well-known firm the Hadfield Steel Foundary Company, Sheffield, have until recently manufactured high-class piercing projectiles by casting only, without any forging operation, which gave uniformly excellent results, and they can supply such projectiles, if preferred. At present, however, they forge all their armor-piercing shells.

At Trubia, as in most factories engaged in the manufacture of piercing projectiles, forging forms a part of the entire process of manufacture. In any case, the annealing of the metal is indespensable after casting without forging, or after forging if forging is practiced. If the metal has simply been cast, annealing has the effect of restoring the molecular equilibrium, which will have been destroyed by the unequal cooling of the steel in the metal mould, and the equilibrium imparted by annealing puts the piece into good condition

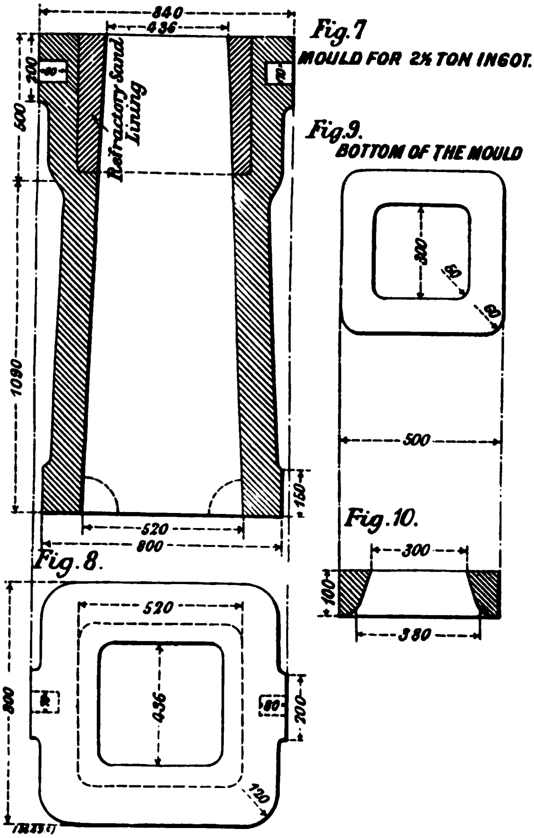
to undergo the subsequent heat treatment. As regards hardening and tempering, these are absolutely indespensable operations, but the final hardening of the point presents the principal difficulty in the manufacture of the projectile. At Trubia projectiles undergo two hardening processes: the first by quenching in oil, followed by tempering, and the second when the mechanical work upon the projectile is completely finished, with the exception of putting on the saltire. This final hardening operation is the more important of the two, being that which gives to the point of the projectile that superior hardness which enables it to attack the hardened surface of the plate, and completely pierce it, whether striking it direct or at an oblique angle. The remainder of the projectile does not require to have the same degree of hardness, since, once the point has penetrated, the body of the projectile passes the hole without difficulty, and serves no other purpose than to impart the energy required to complete the work of total perforation. If it is not possible to harden the point equally throughout its whole thickness, it must at least be externally of an intense hardness, which may gradually diminish towards the interior, as in the case of the Palliser projectile, where this effect was produced by casting the point in a metal mould.

Concerning the tempering of the point of piercing projectiles, with a view to removing to some extent the effect of the unstable equilibrium due to hardening, the practice is not to temper them after hardening, as it is considered preferable to run the risk of possible fracture rather than reduce the hardness in any degree. The whole projectile is, however, submitted finally to a gentle heat-treatment which, as far as possible, ensures it against fracture due to any sudden and extreme changes of atmospheric temperature to which it is likely to be exposed.

At Trubia the steel intended for the manufacture of piercing projectiles is melted in the open-hearth furnace. On the Continent and in England crucible steel is used for the purpose, because the crucible process has always been considered the best for obtaining a material of the greatest purity, as required for this very special product; but, as stated in the author's previous paper on the manufacture of guns, it is possible to produce in the open-hearth furnace a steel so low in phosphorus and sulphur as to be serviceable for making projectiles. For that purpose the very best and purest materials, such as Swedish iron and puddled blooms of Bilbao hematite iron, are employed. The ferro-manganese, ferro-chrome, nickel, and ferro-silicon, used as additions, are the purest obtainable of this class of metals. For the oxidation of the charge Campanil ore is used of the best quality to be found in the Bilbao district. The melting and refining processes are conducted with the greatest care, so as to avoid oxidation of the bath; and should it become oxidized, deoxidizers are added at the end of the heat. The ferro-chrome and nickel additions before charging are preheated in a special furnace alongside of the melting furnace, so as to avoid cooling the bath. The charge is not completely decarburized, but is tapped when the colorimetric analyses at the end of the refining operations indicate that it has reached the requisite degree of carburization, taking into account, of course, the carbon in the ferro-chrome added to the bath.

The metal, when finished, is poured into moulds of square section with rounded corners. They are lined at their upper ends with refractory material, intended to keep the metal fluid at the top as long as possible, in order to feed the shrinkage of the steel as it cools, thus largely preventing pipe. The ingot moulds are shown in Figs. 7 to 10, from which it will be clearly inferred that

compression of the ingots is not practiced at Trubia. The author still maintains his opinion, previously expressed, that, provided the ingots are free from blowholes and poured in moulds lined at the top, compression does not materially improve the physical and mechanical properties of the steel, the only substantial advantage being a saving of metal. The author's attention was lately drawn to the series of experiments carried out by Heyn* and Bauer at the Gross-Lichterfelde Testing Laboratories in order to determine what improvements in the physical properties of the steel are effected by the Harmet process of fluid compression. The investigators adopted the

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only rational method for the study of the question—that is, they divided the charge into two equal parts, one of which was cast into ingots in ordinary metal moulds, and the other into ingots which were compressed by the Harmet process. Three kinds of steel were examined: medium hard, hard, and hard nickel steel. From these three classes of compressed and uncompressed material sections from the top, middle, and bottom of the ingots were rolled in I-girders, from which test-pieces were cut and subjected to the usual mechanical tests, the results of which show in general that the girders rolled

* *Mitteilungen aus dem Kgl. Materialprufungsamt*, vol. xxx., page 176.

from the sound part of the uncompressed ingots were not inferior in any respect to those rolled from the compressed ingots.

The forging of piercing projectiles is an operation requiring the greatest care. Taking account only of the carbon percentage, the material may be classed as hard steel, and more completely so when it is a chromium steel. It is of great importance that the ingot should be preheated before introducing it into the reheating furnace, and even then it is desirable that the furnace should be at a sufficiently low temperature. Unless these precautions are carefully observed the ingot is likely to fracture transversely, as has more than once happened within the author's experience in Trubia. The reheating having been carefully performed in this manner, the ingot of 2½ tons is forged under the press until it is circular in section throughout its length, and of a diameter which exceeds that of the finished projectile by just so much as to allow the necessary machining. The greater part of the head is then removed by cropping. The blank is then reheated and the point is forged, the blank receiving the form shown in Figs. 11 and 12. The annealing operation is now necessary to restore to the material the conditions of equilibrium which have been changed by the work of forging. The annealing is performed at the temperature deduced from the cooling-curves, and, the operation being complete, the blank is passed to the machine-shops.

*Fig. 11.* ARMOUR-PIERCING PROJECTILES FOR 30·5 CENTIMETRE GUN FORGED FROM A 2½ TON INGOT

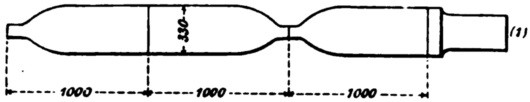
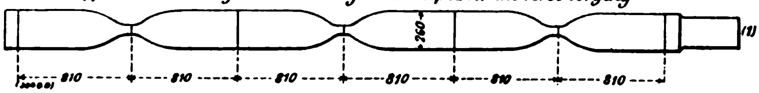



*Fig 12*
ARMOUR PIERCING PROJECTILES FOR 24 CENTIMETRE HOWITZER FORGED FROM A 2500 KILOG.S INGOT.
*(1) Upper end of the Ingot after cutting off the top after the first forging*

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In the machine-shop projectiles are first cut to length, and then bored out in order to form the cavity intended to receive the explosive charge. At the same time the cylindrical exterior and the point are turned up in the lathe, and the projectile is then ready for hardening in oil.

*Hardening and Tempering.*—Though it is not necessary that the whole projectile should receive the intensive thermal treatment which is required to give to the point the hardness necessary for piercing, it is considered, nevertheless, that the hardening of the entire projectile in oil is extremely beneficial. As the result of this operation, which must be followed by tempering, the material acquires an extremely fine grain, and certain notable physical properties, as shown in the table on page 358, giving the results of the tensile tests. If the three characteristic tensile properties of the chromium steel are good, the corresponding properties of the chromium-nickel steel may be said to be quite surprising. It is inconceivable that any other material than the chromium-nickel steel can show a combination of properties equal to the elastic limit, the yield-point, and the elongation per cent of this steel, particularly when it is considered that this latter amount is measured in a length of 2.4 in.

For the oil-hardening a vertical furnace, heated by a gas-producer, is provided. The projectile is heated about 100 deg. above its critical point, the temperature being measured by a Le Chatelier pyrometer. The hardening is then performed in an oil-bath of a capacity equal to ten times the weight of the projectile. The tempering is carried out at a temperature of 400 deg. to 500 deg. Cent. Having been oil-hardened and tempered, the final treatment is given to the point, and the projectile is now finished with the exception of fitting the saltire.

*Chemical Analysis*

| C. | Mn. | Cr. | Ni. | Si. | S. | P. |
|---|---|---|---|---|---|---|
| per cent | per cent | per cent | per cent | per cent | | per cent |
| 0.848 | 0.381 | 2.311 | — | 0.163 | — | 0.020 |
| 0.818 | 0.294 | 2.371 | — | 0.220 | — | 0.030 |
| 0.485 | 0.582 | 0.749 | 2.545 | 0.400 | — | 0.040 |

*Tensile Tests*

| Nature of Test | Elastic Limit | Breaking Strain | Elongation | Observations |
|---|---|---|---|---|
| | tons per sq. in. | tons per sq. in. | per cent | |
| Along the grain | 21.28 | 45.53 | 20.5 | Chromium steel for a 15-cm. projectile, annealed. |
| Across " | 19.35 | 38.37 | 21.0 | |
| Along the grain | 35.47 | 51.11 | 18.5 | Chromium steel for a 15-cm. projectile, quenched in oil and tempered. |
| Across " | 33.54 | 43.53 | 13.0 | |
| Along the grain | 57.76 | 67.08 | 19.0 | Chromium nickel steel for a 15-cm. projectile, quenched in oil and tempered. |
| Across " | 56.01 | 65.79 | 11.5 | |

After receiving the final heat treatment the projectiles remain for about eight or ten days in the hardening department, at the end of which time, if they have not fractured, their capacity to resist sudden changes of temperature is tested. The object of this test is to ascertain whether a projectile can withstand, without breaking, a sudden change of temperature of about 60 deg. to 70 deg., which is a greater variation than is likely to occur in extreme climates. The test is performed by placing the projectile for a certain time in boiling water until it attains that temperature, and then plunging it suddenly in cold water.

*Breakages.*—Though it very rarely happens that projectiles fracture on being hardened in oil, fracture may occur after the point has undergone the final heat-treating operation. In view of the very drastic nature of this treatment of the metal, which, if it contained the simple equivalent of carbon,

would be classed as very hard, and considering also the thickness of the point where it joins the cylindrical portion, it is difficult to carry out the hardening operation in such a way as not to produce internal stresses. Special precautions are necessary, on account of the fact that the operation introduces a state of unstable equilibrium in the material and is not followed by a tempering process, which would relieve these abnormal stresses. The effect of this very rapid quenching of the surface, though somewhat relieved by the heat yielded up by the internal layers, cannot fail to create considerable tensile and compressive stresses, sometimes of a magnitude sufficient to overcome the cohesion of the molecules and produce fracture. When this delicate hardening operation was first practiced, it was a frequent occurrence for the projectile to crack, but that rarely happens now, and, when it does, the cracks only become visible after several days. Sudden changes of atmospheric temperature must be avoided, the slight stresses due to such changes, when added to those caused by hardening, being sometimes sufficient to produce fracture. The cracks occur in the point at a greater or less distance from the extremity, and in a plane normal to the axis. Some idea may therefore be formed of the enormous stresses in the metal produced by hardening. It is within the author's recollection that on a winter morning, when the temperature suddenly rose several degrees, the points of six or eight projectiles which had been hardened about eight days previously developed cracks. Such cracks seldom occur in the plane of the diameter, but almost always vertically through the point. Fracture is not always due to physical causes only, as it has been proved that by diminishing the percentage of manganese the number of breakages is also diminished.

*The Manufacture of the Cap.*—Since the introduction of cap projectiles the advantage has been recognized of making the cap of a softer material than that of the projectile, and it is now considered good practice to use an extra mild steel. These opinions notwithstanding, a quaternary steel is used at Trubia, though with a lower percentage of chromium and nickel than that contained in the projectile steel. The following is the composition of a steel for caps which has given excellent results:

| | Per Cent. |
|---|---|
| Carbon | 0.40 to 0.45 |
| Silicon | 0.10 " 0.15 |
| Manganese | 0.50 " 0.60 |
| Phosphorus | 0.3 |
| Sulphur | 0.3 |
| Chromium | 0.30 " 0.35 |
| Nickel | 1.30 " 1.50 |

The tensile properties are shown in the following table:

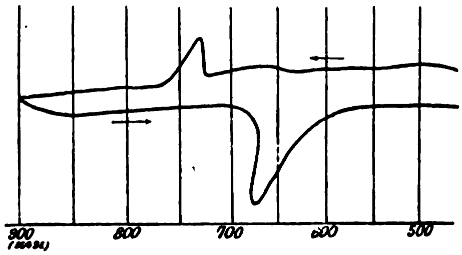
| —— | Elastic Limit | Breaking Strain | Elongation |
|---|---|---|---|
| | tons per sq. in. | tons per sq. in. | per cent. |
| Annealed after forging | 24.41 | 47.08 | 10 |
| Hardened in oil and tempered | 40.63 | 53.53 | 12 |

The steel for the caps is melted in an open-hearth furnace, and is composed of the best materials, the operations of melting, refining, and tapping

being performed with the same degree of care as is bestowed on the material of the projectiles. The steel is forged in round bars after removal of all surface cracks from the ingot, and is then annealed and cut into short lengths convenient for stamping. After stamping, the caps are oil hardened and tempered in the same manner as the projectile, and then undergo the final thermal treatment.

The heating and cooling curves of the steel for the caps is shown in Fig. 13, from which it will be seen that the critical points in heating and cooling are not more than 50 deg. Cent. apart.

*Fig. 13.*
*HEATING & COOLING CURVES OF CHROMIUM-NICKEL STEEL FOR PROJECTILE NOSE-CAPS.*
*Upper Curve, Heating; Lower Curve, Cooling.*




*Firing Tests.*—After having described the manufacture of piercing projectiles, it may be of interest to give some account of their behavior on the testing ground. Up to the present the only tests carried out against chromium-nickel-steel plates hardened by the Krupp process with illuminating gas have been performed with projectiles of 15 cm., or, say, 5.9 in. caliber.

Many tests have been performed, of which those carried out on the two days, September 26 and December 17, 1905, will be more particularly described. On the first of these days a Schneider plate, 180 mm. (7.1 in.) thick, was under fire. The plate, which was of nickel steel, with a small percentage of chromium, and hardened by the Krupp process, was placed at a range of 100 m. (320.7 ft.) from the mouth of the gun, and was fixed at right angles to the path of the projectile. The tests on both days were performed by a quick-firing gun, which discharged a projectile of 50 kg. (110.37 lb.).

The result of the first day's firing is summarized in the following table:

| No. of Discharge | Type of Projectile | Velocity of Impact | Energy | Diameter of Perforation | | | |
|---|---|---|---|---|---|---|---|
| | | | | Entry | | Exit | |
| | | | | H. | V. | H. | V. |
| | | ft. | ft.-tons | in. | in. | in. | in. |
| 1 | Chromium steel | 2243 | 3923 | 6.7 | 6.3 | 11.8 | 9.05 |
| 2 | Chromium nickel steel | 2291 | 4085 | 5.9 | 5.9 | 9.05 | 10.6 |
| 3 | Chromium steel | 2203 | 3450 | 7.8 | 6.7 | 11.4 | 14.96 |

Of the three projectiles, the chromium-nickel-steel projectile was the only one which passed through the plate without either breaking or undergoing deformation: even the copper saltire was retained. No. 1 projectile broke into several pieces, of which twelve were recovered, the largest being the point, weighing 18 kilogrammes. Of projectile No. 3 fourteen pieces were recovered, the largest also being the point, weighing 14 kilogrammes. The three projectiles are shown in Fig. 14. Each projectile pierced a clean hole through the plate. In this test the superiority of the chromium-nickel projectile was clearly manifest, as one would expect from the marked superiority of its tensile properties.

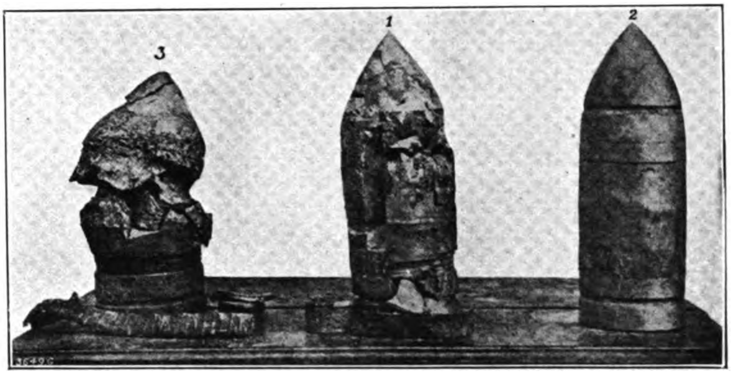



FIG. 14. 1382

On the second day, December 27, another Schneider plate of the same thickness was fired at, the only difference being that, instead of placing it vertical to the line of firing, it was set at an angle of 10 deg. 20 min. The result of the test is summarized in the following table:

| No. of Discharge | Type of Projectile | Velocity of Impact | Energy | Diameter of Perforation | | | |
|---|---|---|---|---|---|---|---|
| | | | | Entry | | Exit | |
| | | | | H. | V. | H. | V. |
| | | ft. | ft.-tons | in. | in. | in. | in. |
| 1 | Chromium steel | 2188 | 3721 | 5.9 | 6.3 | 9.05 | 9.8 |
| 2 | Chromium nickel steel | 2147 | 3587 | 6.3 | 6.3 | 11.8 | 7.87 |

Both the first and second projectile pierced the plate. As in the previous test, the chromium-steel projectile broke into many pieces, of which ten were recovered, weighing altogether 33 kg. The chromium-nickel-steel projectile was recovered intact, at a distance of 8200 ft. to 9830 ft. The point sustained a light conchoidal fracture, as shown in Fig. 15, page 362.

In view of the excessive energy of the chromium-nickel-steel projectile, which had traveled a great distance after piercing the plate, tests were afterwards made with a lower velocity of impact. The velocity was reduced to

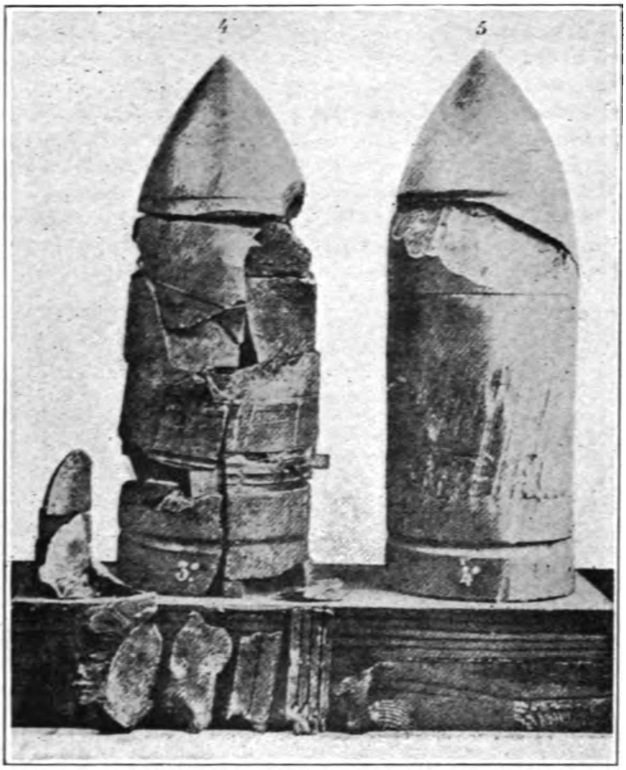



FIG. 15. 1363

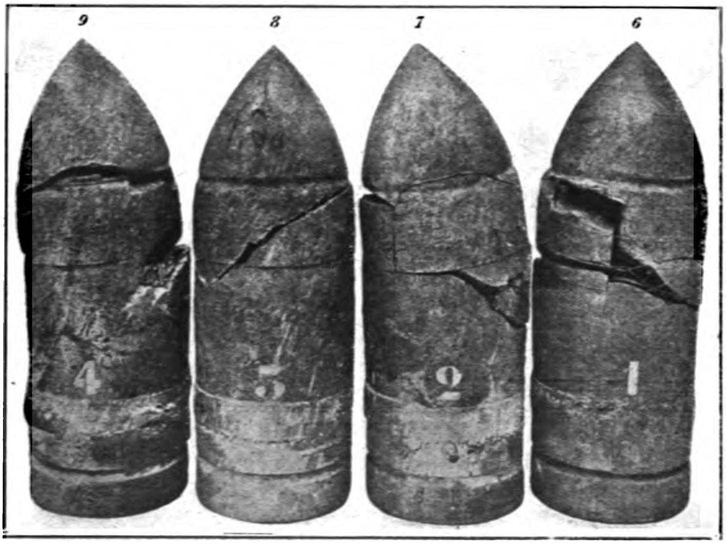



FIG. 16. 1364

1867 ft., the energy being 2705 foot-tons. The only difference noted was that at these low velocities the chromium-nickel projectile broke, but only into a few pieces, and some of them, as shown in Fig. 16, No. 8, were only broken into two parts. The energy of impact of that projectile was 2911 foot-tons. All four projectiles shown in Fig. 16 were of chromium-nickel steel.

—*Engineering* (London).

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## ARMOR-PIERCING PROJECTILES*

Dr. Adolphe Greiner brought up a communication from M. Girod, who stated that at the works of the Girod Company the manufacture of projectiles had now been undertaken. At the outset they had no practical experience in that branch of manufacture, and the first step taken was to obtain a metal which would give the proper shading down of the hardness both lengthwise and throughout the cross-section of the projectile. With a view to obtaining this effect they had conducted an investigation as to the composition of metal which would be the best for this purpose and which would give, after due heat treatment, the proper hardness which within certain limits would be a function of the temperature attained at each point considered separately. The steel employed had the following composition:—Ni 4 per cent; Cr 1.5 per cent; C 0.5 per cent, with from 0.2 to 0.5 per cent of molybdenum, vanadium, or tungsten. The metal was annealed at a temperature of about 600 deg. C., and gave a structure which, while still stiff, was sufficiently supple not to break under the whipping action observed in oblique firing, and but little liable to swell under the enormous shock on the plate. Out of a lot of 500 14-in. shells recently manufactured there had not been during the process of manufacture, or afterwards, a single instance of cracking. These manufacturing results were confirmed in the firing trials, in which they obtained regularly the following results on a Krupp cemented plate. The firing was at an angle of 15 deg. from the normal, the striking velocity being about that determined experimentally for bare penetration, the thickness of the plate being equal to, or a little above, the caliber of the projectile. The projectile passed through the plate, remaining entire and with only a small alteration of shape. In these trials the shell was always capped, the shape, length and style of cap being similar to that in the shells experimented on by General Cubillo. The striking velocity in the latest trials of 12-in. shells against hard plates at an angle of 15 deg. was 2000 ft.

Sir Robert Hadfield, in winding up the discussion, referred to the difficulty of replying to points in the paper which confronted one who was himself a manufacturer of projectiles. They were much indebted to General Cubillo, who had given them a previous paper on this subject. It was often forgotten how much the steel industry owed to Spain in this branch of work. He could not say all he would on the question of projectiles because the Government very properly imposed a certain amount of secrecy upon those doing Government work, but he thought it could be claimed that Sheffield could still hold its own in projectile manufacture. The difficulties involved were not easy to overcome. The largest caliber shells—of 15 and 16 in.—struck their blow, which could only be called a punch, at 50,000 foot-tons of

* Extract from the proceedings of the Iron and Steel Institute at Brussels in September, 1913.

energy. That blow was made in the millionth part of a second, and the effect concentrated on the extreme point of the shell so that it could be easily understood that the material employed must be well prepared, well hardened, and well tempered. General Cubillo had not told them all; it could not be expected that he would do so; but he had drawn the veil a little from the secrets of the hardening shop. Hardly enough stress had been laid on the importance of the cap, as the best projectile in the world would be simply shattered into fragments on the plate if it were not provided with a suitable cap. The modern development of the projectile cap had been made in English works. The latest form of cap was the hollow one. which was found to possess advantages over other types. The reason was difficult to explain, as it was not easy to say what happened on impact, but it was believed that by taking away some of the metal the cap buried itself, and the shell was enabled to bring its enormous energy to bear on the plate. As an illustration of what projectiles were capable of, a 6-in. Hadfield projectile had been fired three times against a 6-in. plate before the projectile was broken into pieces. A 9.2 projectile had been fired against an 18-in. wrought-iron plate and had been very little damaged after that test. A recent test was the firing of a 12-in. projectile against a Krupp cemented plate, in which the shell passed completely through the plate and was found three miles away in an undamaged condition. With regard to the hardening question, it was absolutely necessary to take the greatest care in the preparatory stages of projectile manufacture.—*The Iron and Coal Trades Review.*

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## BIG NAVAL GUNS

The improvements which have recently been introduced have greatly increased the resistance of modern armor. This result is not due to any new discovery, it is the fruit of much patient experiment and investigation. Although, therefore, the thickness of the main armor on any warship is no greater than it was formerly, its capacity to withstand the direct impact of armor-piercing projectiles is far in advance of the old types of armor plates.

The latest modified Dreadnought type of vessel, with its huge displacement and heavy armament, may have no thicker armor on its main belt than that on much older ships, but as this has a much higher resistance there is a great gain in protection. Formerly, too, the automobile torpedo of the Whitehead or Schwartzkopff patterns was more or less ignored as a factor in naval action, except as a *coup de grace*, or at best when at close range. Now, however, owing to the introduction of the gyroscopic steering arrangement and the heating of the compressed air, the accuracy and range of action of modern torpedoes have been so much increased that they must be considered, when in skilled hands, a serious menace even at distant ranges.

This fact and the fear, only too well founded, of great damage being done by high explosive shells, when fired at the unarmored portions of a ship, have combined with other reasons to increase the future battle ranges to 8000 m. or 9000 m. No doubt when the enemy is being outmatched the victor will endeavor to choose his own position, and close in to short effective ranges in order to complete the mastery.

These long ranges and the additional armor resistance have rendered necessary a forward movement in gun power. It is quite admitted that

with direct hits, *i.e.*, when the projectile strikes the plate at right angles, the largest heavy gun until recently contemplated, viz., the 305 mm. [12-inch], could perforate the thickest ordinary armor at the long ranges named above. But in action glancing hits are the general rule, and the chance of a direct hit even at close range is extremely remote. A skilful commander will endeavor always so to maneuver his ship as to present to the enemy's fire the most oblique target possible.

As is well known, the 305 mm. [12-inch] gun has gradually been lengthened from 35 calibers to 40, then to 45 calibers, and finally to 50 calibers in length. The weight of the propelling charge and the chamber pressure have also been progressively increased, so that a very large addition in power has resulted. This increase in power is due to the higher velocities obtained—velocities only attainable by the employment of relatively large powder charges. Small chambers were certainly reintroduced by the Armstrong Company some years ago, and guns now conform with this and other new principles, such as, for instance, a different form of chamber, etc., but it has to be admitted that these high velocities, whether employed with small or with large ordnance, are mainly responsible for the rapid wear of the bores of the guns experienced. Some authorities contended at one time that this erosion was not experienced with guns made by Krupp, but this statement is now known to have been erroneous, and based on an entirely incorrect hypothesis. The reasons for the rapid wear or erosion in high velocity guns are quite evident in the light of recent research, and are briefly as follows:—In order to obtain a high velocity it is necessary to use either a large charge at a comparatively low density of loading or a somewhat smaller charge at a high density—supposing other conditions to be the same—that is to say, the same initial velocity can be obtained with the same maximum chamber pressure, either by the use of a large charge of small dimensioned powder loaded in a large chamber or by a rather less charge of large dimensioned powder in a small chamber.

Now, it is admitted that the erosion of equally proportioned guns is, for similar velocities, dependent on some function of the caliber, and, further, that in guns of any particular caliber it depends on the weight of charge. At first sight it might therefore be argued that the smaller charge of large-sized powder would be the best; but consulting Sir Andrew Noble's researches —see Vol. ccvi., Phil. Trans., Royal Soc.—the following table has been compiled showing for various explosives certain calorific data by which the ballistic energy and the erosive quality of different types of powder may be directly compared:—

| Density of charge in a closed vessel | 0.10 | .20 | .30 | .40 | .50 |
|---|---|---|---|---|---|
| *Volume of Gas per Gramme of Explosive* | | | | | |
| Cordite Mark I | 878.5 | 875.5 | 848.0 | 820.0 | 798.8 |
| Cordite M.D. | 948.0 | 913.5 | 873.0 | 832.0 | 789.5 |
| Nitro-cellulose | 980.0 | 934.0 | 883.0 | 841.0 | 802.0 |
| *Units of Heat per Gramme* | | | | | |
| Cordite Mark I | 1174.0 | 1170.5 | 1186.5 | 1223.4 | 1287.0 |
| Cordite M.D. | 959.0 | 961.5 | 1008.0 | 1090.0 | 1178.0 |
| Nitro-cellulose | 818.0 | 850.5 | 900.5 | 954.5 | 1015.0 |

*Temperature of Explosive "C"*

| | Deg. | Deg. | Deg. | Deg. | Deg. |
|---|---|---|---|---|---|
| Cordite Mark I............. | 3100 | 3760 | 4435 | 4960 | 5270 |
| Cordite M.D............... | 2565 | 3240 | 3961 | 4551 | 5051 |
| Nitro-cellulose ............ | 2415 | 2815 | 3335 | 3832 | 4212 |

It will be observed that with Cordite Mark I, which contains the largest percentage of nitro-glycerin, the gas volume produced is the smallest, while the units of heat are greatest; further, that as the proportion of nitro-glycerin in a powder is reduced, the gas volume increases and the units of heat decrease.

The energy of each powder can be approximately gauged by multiplying the volume of gas per gramme by the units of heat per gramme; thus, Cordite Mark I, as might be expected from the large percentage of nitro-glycerin it contains, has the greatest energy, Cordite M.D. is next, and pure nitro-cellulose has least energy. The weight of charge necessary to obtain the same ballistics will therefore be greatest for the pure nitro-cellulose and least for Cordite Mark I. Roughly, a charge 10 per cent heavier will be required of nitro-cellulose than of Cordite M.D., and of this about 10 per cent more than of Cordite Mark I.

Further, it is a well-known fact that pure nitro-cellulose must, in order to obtain the highest value from it have a higher loading density than Cordite M.D., and although when maximum pressure takes place the density of the burnt portion of the charge is considerably less than the loading density, it may be higher with the nitro-cellulose than with Cordite M.D.; consequently, the temperature of explosion would in that event be as high, or perhaps even higher. The figures given in the table above fully account for the facts which have actually occurred, viz., that the use of pure nitro-cellulose powder, or, indeed, of any powder which requires a high loading density, has increased the erosion instead of decreasing it as was expected.

This digression has been made in order to make clear the effect of the excessive high-density-loading which some artillerists favor, for besides the disadvantage of rapid erosion there is also the certainty of a rapid falling off in ballistics, because any wear in the gun allows the projectile to be rammed further into its seating and increases the chamber space. It is clear if this increase be supposed, for argument's sake, equal for any size of chamber, that it will bear a far greater proportion to a small chamber than to a large one. Further, high density charges of large-sized powder usually give less regular velocities, and therefore also less accuracy than smaller powder at lower densities. The size and shape of the powder chamber require to be carefully considered and proportioned to the requirements of the gun.

It may be assumed that a 50-caliber gun is the longest which is likely to be approved, as, owing to the flexibility of long guns, the accuracy is liable to be poor in comparison with that of shorter guns; consequently, the limit of power has been reached with the 305 mm. [12-inch] gun, by which a service velocity of 915 m.s. has been obtained with a projectile weighing 850 lbs. There is no real difficulty in obtaining even higher velocities, except for the extremely rapid erosion and the serious reduction in velocity of subsequent rounds which would result.

The dependence of erosion on caliber and weight of charge is well illustrated by the following table, which has been taken from one lately compiled from actual experience:—

| Caliber of gun. | Approximate initial velocity | Approximate life of gun with service charge |
|---|---|---|
| mm. | m.s. | Number of rounds |
| 233 | 840 | 450 |
| 233 | 885 | 300 |
| 305 | 825 | 280 |
| 305 | 900 | 160 |
| 343 | 760 | 450 |

Here, the 305 mm. [12-inch] 50-caliber gun which has an initial velocity approaching 900 m.s. when firing about 140 kilos. of M.D. Cordite, has an average life of 160 rounds, whilst a 343 mm. [13.5-inch] 45-caliber gun firing a slightly smaller charge of the same cordite giving an initial velocity of approximately 760 m.s. has an average life of 450 rounds. Assuming the usual ratios, and admitting a proportionate amount of erosion, a 356 mm. [14-inch] 45-caliber gun, having the velocity of 760 m.s., would fire about 420 rounds, and a 381 mm. [15-inch] 45-caliber gun 350 rounds, before these large guns would require to be provided with a new barrel or liner—after which they would again be equal to new guns.

The operation of lining a gun is a somewhat protracted one, so that it is imperative that there shall be a reserve supply of guns to take the place of those worn out, and that the caliber and velocity of the gun shall be so chosen as to combine the longest possible life with ample power.

There are several ways of augmenting the striking power of the gun, viz.:—(1) By increasing the caliber; (2) by increasing the proportional weight of the projectile; (3) by shaping the ogive of the projectile with a larger radius than usual; (4) by an increase in velocity.

(1) It has been shown that according to actual practice a gun of large caliber having a moderate initial velocity is able to fire a far greater number of full rounds than a smaller one having a high initial velocity. This is of much interest and of particular importance, as it will be shown that the perforating energy of the larger gun with its moderate velocity is superior at the longer ranges to that of the high velocity smaller gun; and by a slight increase of initial velocity it would be superior at all ranges. It is preferred, however, not to magnify this unduly, in order that other important points may have full and unprejudiced consideration.

(2) By increasing the proportional weight of the projectile a greater amount of the energy of the powder is employed, and the armor-piercing energy is superior to that of the lighter projectile at all ranges; but it has to be borne in mind that increase in the weight of the projectile increases the chamber pressure, and the charge may require adjustment.

(3) By forming the heads of capped projectiles of a larger radius than formerly, the air resistance is much reduced, and consequently the projectile arrives at the object with a higher velocity than with the ordinary shape of ogive. This increase in striking velocity, combined with the use of the cap, greatly increases the perforating power of the projectile.

(4) By increasing the initial velocity, it is evident that an increase in power is obtained, supposing the weight of the projectile to remain unaltered.

Until recently, it has usually been laid down as an axiom that hard-faced armor should be attacked by a projectile whose caliber is approximately equal to the thickness of the plate; but when the improved armor had passed the experimental stage, it became manifest that a corresponding

forward movement in gun power was imperative. The difficulty was accentuated by the fact that a comparatively high striking velocity was necessary to ensure the perforation of the improved armor when attacked by its own caliber of shell, and it became evident that it was well-nigh impossible to preserve the explosive charge of an armor-piercing shell from bursting when striking the plate, in which case no effect on material behind the plate could take place.

By increasing the caliber and the weight of the shell proportionately, the striking velocity necessary to perforate the same thickness of plate is much reduced, so that an armor-piercing shell filled with high explosive can be effectively burst after perforating the plate at much longer ranges.

The experience which has been gained regarding the effect of large projectiles after perforating modern hard armor has led to the introduction of what is generally termed "super-caliber" projectiles, or projectiles of a caliber superior to the thickness of the plate they are intended to attack. Moreover, since the weight of the bursting charge is approximately proportional to the total weight of the shell, or approximately as the cubes of the caliber, the destructive or bursting effect of the heavier shell is greatly augmented, as it also rises more or less in the ratio of the weight of explosive or as the cube of the caliber.

There is a tendency to increase the proportionate weight of the shell, and this may be achieved without greatly affecting the general disposition of the artillery; but an increase in caliber of the gun is necessarily limited by the number of guns the vessel is to accommodate, and the total weight which can be admitted for the armament. The thickness of armor is still more strictly limited, since it forms a very large proportion of the weight carried on the ship. It follows, therefore, that while the thickness of the armor must remain nearly constant, the caliber of the gun may be increased to some extent. The general conditions governing this increase are:—(1) the greatest weight which can be allowed to the armament; (2) the number of guns required; (3) their disposition within each turret, *i.e.*, as twin, tripple or quadruple guns; (4) the disposition of the turrets in the ship, *i.e.*, whether any of them are to be superposed, as this affects the weight of the barbette armor; (5) the weight of the projectile, and the number of rounds of ammunition to be carried by the ship.

It is obvious that for a similar type of guns and turrets, the larger the caliber the larger will be the turret; and although modern ingenuity has done much to reduce the ratio, it still exists to some extent.

Some foreign critics assert that wire guns are much heavier than the built-up guns made by continental constructors. This is no doubt true, but if it be assumed that the metal of which the guns are manufactured is equally well disposed in either case, it requires no proof that the British gun must be the stronger. As a matter of fact, by giving the small margin of strength allowed by continental makers, there would be no difficulty whatever in making a wire gun of less weight than the continental gun. The method of allowing a large margin of strength in all guns is that adopted by the British Government, and the freedom from serious accidents with English made guns may be attributed in a great measure to this good practical rule. No instance of failure, when firing under ordinary conditions, has ever occurred with wire guns of Elswick construction; and even when firing high explosive shell, it is unlikely, with the high factors of safety allowed in the wire system, that any gun would actually burst with either armor-piercing or semi-armor-

piercing shell filled with high explosive. In case of a premature explosion, on the other hand, it is certain that guns built up of solid elements would be entirely destroyed, with the probability also of involving a good deal of damage to the ship, and the certainty of terrible loss of life. It is not asserted that a gun on the wire system would be uninjured. No doubt, the bore would be considerably damaged at the position where the shell burst, but, although it might not be possible to fire the gun again, the ship's structure would remain intact.

As regards longitudinal strength, the guns as made by British manufacturers, such as Armstrong, are certainly as strong, if not stronger, than guns constructed on any other system. No instance has ever occurred of a gun built on modern English lines failing from want of longitudinal strength—it is otherwise with guns constructed to other designs. A notable instance recently arose, when 24 cm. [9.5-inch] guns of French design failed at proof, fortunately without involving loss of life, but a number of guns of this new model had to be withdrawn from service. It is gathered that they were made on a similar system to the same caliber of gun of an earlier type, so that there can be little doubt that the margin of longitudinal strength of all these guns is small.

Additional point is also given to this important qestion by the recent disastrous failure of the breech end of a 305 mm. [12-inch] gun at Pola, and by the failure during proof—fortunately without loss of life—of another 305 mm. [12-inch] gun made by a United States firm.

No difficulty exists in making a light type of gun, but it must be remembered that the recoiling energy is in the inverse ratio of its weight; so that a gun of very light weight has a correspondingly large amount of recoiling energy, and this energy can only be absorbed either by arranging for a sufficiently long recoil or by strengthening up the whole structure of the mounting in order to resist the high stresses produced. It will be at once seen that in either case the weight of the mounting must be increased for:—The long recoil involves a larger turret and consequently a larger target exposed to hostile fire, or the higher stresses require greater strength and therefore a greater weight of material. The weight of the gun should therefore be governed entirely by considerations (*a*) of safety; (*b*) of the effect of the weight of the gun on the total weight of the gun and mounting, care being taken that the mounting has sufficient strength to resist all possible stresses which may be brought upon it. It is for these and similar reasons that the leading British firm so strongly advocates guns of ample weight; for it is clear that even if the light gun be sufficiently strong an economy in the weight of the gun does not generally mean a reduction in the total weight of the armament, if due regard is given to questions of strength. It is well known that ballistic tables have been specially compiled abroad for the purpose of showing off light guns giving a high initial energy per ton of gun; but these tables ignore all particulars of the mounting and other equally important factors, and consequently impart an entirely fictitious impression.

Many attempts have been made to reduce the weight, and consequently the strength of parts of the mounting, but with only indifferent success. In one case, the defective structure had to be entirely remade, thus preventing a very valuable ship being placed in commission for several months.

Just lately questions have been raised in connection with the trials of triple gun turrets which give additional point to these remarks. The triple gun turrets, designed and manufactured by the Armstrong Company, on the

Italian battleship *Dante Alighieri,* have had a most searching trial, the 305 mm. [12-inch] guns being fired with full service charges in every possible way, and the three guns in each turret were also fired simultaneously. The installation withstood these trials without showing the least sign of distress, and the authorities have expressed their entire satisfaction.

The triple gun turrets, which were designed on the Continent, on the Austrian battleship *Viribus Unitis,* have carried out a similar series of trials, but not with the same success. The report states that the three guns in each of the forward turrets were fired right ahead and simultaneously by electricity. The result was that one turret was put completely out of action, being lifted clean off the roller path, and the ship has been in dockyard hands under repair ever since. The report further remarks that "if the three guns cannot be fired simultaneously, it is difficult to see what advantage the triple turret gives."

In another report dealing with the behavior of the guns in the Italian navy—all of which were made by Armstrong's—during the Tripoli war, it is stated that the Italian Ordnance Department has been well satisfied, as during the whole of this campaign no accident had occurred to the navy guns, although 32,046 projectiles had been fired from them.

Another important influence on the weight of the mounting is, of course, the extent to which alternative systems of power and hand working are employed. Further, in order that the turret may be easily and steadily trained when the ship is rolling or on an uneven keel, it is the invariable practice at Elswick so to design the mounting that the center of gravity of the revolving system is on or near the center of revolution. This very important consideration involves a greater weight in the turret than when it is ignored, but allows the turret to be far more easily trained at all angles of heel, etc. In comparing the weights of designs of guns and mountings, it is therefore important that all these points should be taken into account; and it is manifest that comparisons can only be of value when the same thickness of armor is provided for in the designs which are being compared.

Enough has been said to prove that guns of the British wire system can be made of as light a weight as those on the solid element system; that these are far stronger circumferentially, and at least as strong longitudinally as those of the solid element construction; and that by adopting the British type, *i.e.*, a moderately heavy gun, the factor of safety in both directions can be materially increased.

Authorities frequently desire some expression of opinion as to the comparative advantages of a gun of larger caliber over that up to the present adopted. Such comparisons are difficult to exhibit, as so many factors and considerations have to be taken into account; but by adotping a standard type of turret and mounting, these uncertainties are to a certain extent co-ordinated. On this supposition the following particulars may be useful for considering the respective merits of the 356 mm. [14-inch] of 45 calibers and the 381 mm. [15-inch] of 40 calibers in length. These two types are taken as the total weights of complete twin gun turrets of the two sizes, do not greatly differ from each other, while the gun of larger caliber offers certain ballistic advantages not to be ignored. In order to form a definite idea of the actual weights of the heavy armament—but excluding the belt and barbette armor, which properly belongs to the ship structure—the armor of the turret has been accounted for, and also the normal proportion of ammunition, viz., 80 full rounds per gun. For one turret the weights will be:—

| | 356/45 metric tons | 381/40 metric tons |
|---|---|---|
| Two guns | 163.00 | 168.00 |
| Turret complete with armor | 509.45 | 554.20 |
| 160 rounds ammunition | 154.43 | 185.33 |
| Total | 826.88 | 907.53 |

Suppose, further, that the ship is to be fitted to receive four turrets, then the total weights, including the steam pumping engines, hydraulic piping, etc., will be:—

| | 356/45 metric tons | 381/40 metric tons |
|---|---|---|
| Four turrets, each with two guns and 160 rounds of ammunition | 3307.52 | 3630.12 |
| Steam pumping plant and hydraulic piping | 103.25 | 103.25 |
| Total weight of heavy armament | 3410.77 | 3733.37 |

These figures naturally show that so far as weight is concerned, the advantage is on the side of the smaller caliber; but it may be assumed that with hydraulic working the rate of fire per minute from either caliber will be the same. Thus, heavier projectiles, with the probability of greater accuracy, can be fired from the larger gun with the same rapidity as from the smaller gun, which will give the former a manifest advantage.

*Range Table for 15 in. 381 mm. B.L. Gun*

| | |
|---|---|
| Caliber of gun | 15 in. = 381 mm. |
| Weight of gun | 82.5 tons = 83,824 kilos. |
| Length of bore | 40 cals. |
| Projectile (4 cal. head) | 1951 lb. = 885 kilos. |
| Muzzle velocity | 2300 f.s. = 701 m.s. |

| Range | Elevation | | Remaining velocity | Length of danger zone for 9.1 m. vertical target | Penetration into K.C. plate |
|---|---|---|---|---|---|
| Meters | Deg. | min. | M.S. | Meters | mm. |
| 1,000 | 0 | 36 | 679 | — | 503 |
| 2,000 | 1 | 14 | 657 | 401 | 479 |
| 3,000 | 1 | 53 | 637 | 256 | 457 |
| 4,000 | 2 | 33 | 617 | 185 | 436 |
| 5,000 | 3 | 15 | 597 | 141 | 415 |
| 6,000 | 3 | 59 | 577 | 113 | 394 |
| 7,000 | 4 | 44 | 557 | 91 | 374 |
| 8,000 | 5 | 33 | 537 | 79 | 354 |
| 9,000 | 6 | 24 | 517 | 68 | 334 |
| 10,000 | 7 | 19 | 499 | 59 | 316 |
| 11,000 | 8 | 18 | 483 | 51 | 301 |
| 12,000 | 9 | 19 | 469 | 45 | 288 |
| 13,000 | 10 | 22 | 456 | 39 | 276 |
| 14,000 | 11 | 30 | 444 | 35 | 265 |

11,300 m., the advantage of the heavier projectile at these distant ranges is more or less balanced; but, again, the possibility must not be overlooked of a large powerful projectile striking some important portion of an enemy's ship and bursting within the vessel. The bursting effect of the projectile becomes one of the most important considerations, and, taking into account that the 381 mm. [15-inch] shell will be at least 26 per cent more destructive than one of 356 mm. [14-inch], and as this is combined with superior accuracy, most careful thought is required before dismissing the larger caliber in favor of the smaller caliber gun.

On the other hand, again, it must not be forgotten that the volume of fire which can be projected from the secondary armament is also of the utmost importance. In fact, it was, according to some authorities, the effect of the incessant rain of 6-in. high explosive shell from the Japanese ships at the battle of Tsushima which so seriously incommoded the crews of the Russian ships as to render them helpless, while none of the thick armor in either the Japanese or Russian ships was perforated.

The armament of 356 mm. [14-inch] guns means a saving of about 322 tons over one of 381 mm. [15-inch] guns, and a considerably smaller ship could therefore be employed; or this weight could be utilized by giving a more powerful secondary armament, as is now being done in many modern battleships. In one at present building at Elswick sixteen guns of 152/50 are being provided.

The question which caliber of gun offers most advantages can only be answered by fully considering what class of ships are likely, during the next few years, to be a possible hostile target; what guns they will be armed with, and their disposition, as well as the thickness and situation of the armor.

—*The Engineer* (London).

## EXPERIMENTS WITH FLAMELESS POWDER IN THE NETHERLANDS

Translated from the German for the JOURNAL OF THE UNITED STATES ARTILLERY by 2nd Lieutenant DONALD ARMSTRONG, Coast Artillery Corps

Since 1907 a board of test in the Netherlands has been conducting experiments with flameless powders. For the field gun the experiments have progressed to such a point that the field artillery regiments in their practice this year will pass judgment on the advantages and disadvantages of the powder. For the field howitzer the experiments had reached such a stage as early as 1910.

A patent for flameless powder in a foreign periodical drew the attention of the board to a changed composition of smokeless powder.

The purpose of the new powder is to have practically no flame at the muzzle on discharge. The advantages of such a powder are obvious; for it will be more difficult than ever to discover the position of guns in action. Now, especially at night, the flame at the muzzle incident to the use of smokeless powder is visible at great distances.

Experiments with field guns show that by day the flash at the muzzle is visible when the crest of the cover does not exceed 1 to 1.25 meters above

the muzzle; while by night a crest of 3 meters above the muzzle does not conceal the flash. If the crest does not exceed .5 meter above the muzzle it is even possible to ascertain the exact position of the piece firing.

Flameless powder was first supplied the board by Dutch powder works. The samples $(2\times2\times2)$* contained to 100 parts nitroglycerin† powder:

Sample I—2 parts potassium carbonate and 5 parts vaseline.
" II—5 parts resinous matter treated with sodium.
" III—5 parts resinous matter treated with calcium.

Two shots were fired with each of the samples; and, in order to determine the difference in the development of smoke and flame, two shots were also fired with smokeless powder $(2\times2\times2)$. The weight of powder charge was 0.485 kg.

The results were:

| mple | Maximum pressures (atmospheres) | Difference between range set and range attained | Observed phenomena |
|---|---|---|---|
| Smokeless powder | 1499 | −110 | Bright flame at muzzle; almost no smoke. |
| I | 870 | −630 | Flame at the muzzle dull, or practically no flame; comparatively a good deal of smoke. |
| II | 1159 | −358 | Little flame in the first shot: considerable in the second. More smoke than with smokeless powder. |
| III | 1041 | −515 | Comparatively bright flame; smoke same as with II. |

In all shots the powder was completely burned. In sample I no flame was visible, and in this respect the end was attained. This sample, however, had a great disadvantage in that the pressure was very small, the muzzle velocity low, and consequently the range too short. The charge would have had to be considerably increased to give the range table velocity. A further disadvantage was the quantity of smoke developed, which in great measure nullified the advantage of the absence of flame.

As a result of these experiments, the powder manufacturers offered two more samples of smokeless powder $(2\times2\times2)$, which contained to 100 parts nitroglycerin powder:

Sample IV—5 parts potassium carbonate.
" V—6 parts resinous matter treated with sodium and 2 parts lead chromate.

* Refers to dimensions of powder grains.—Tr.

† The phenomenon of flame is an effect of the liberation of oxide of carbon in the combustion of the charge. Nitrocellulose powders produce more than do nitroglycerin powders; the latter, however, give off oxide of nitrogen, which tends to erode. See the article *L'erosione delle artiglierie*, by Captain Brevetta, on page 64 of *Rivista di artiglerie e genio*, for July-August, 1911.—*Revue d'Artillerie*.

The following results were obtained:

| Sample | Weight kg. | M.V. meter-sec. | Max. pressures | Observed phenomena 2000 m. in front | Remarks |
|---|---|---|---|---|---|
| IV | 0.510 | 448 | 1400 | No flame at muzzle; considerable smoke. | The firing was observed without telescope. The weather was clear during the firing with the 0.510 kg. charge, and rainy during the remaining shots. |
| | 0.533 | 460 | 1451 | No flame at muzzle; less smoke than before. | |
| V | 0.510 | 390 | 917 | Easily visible flame at muzzle; little smoke. | |
| | 0.650 | 470 | 1417 | Flame same as before; more smoke. | |

Thus, with sample IV, no flame was observed at the muzzle, but there was too much smoke. Consequently the board ordered the composition of the powder to be so changed that there should be less smoke, without increasing the flame at the muzzle.

The powder manufacturers then offered four different samples, of which the grains were 4×4×1. Their idea was to eliminate smoke by a more rapid burning of the powder. Experiments with this powder showed that the change in the grains had little influence on the amount of smoke; but that, in order to secure the same muzzle velocity, the size of the charge would have to be materially increased. Experiments with these samples were accordingly discontinued.

Experiments were then commenced with the following foreign samples:

1. For the field gun: 25 kg. tubular nitrocellulose powder, length of tube about 202 and 217 mm., external diameter 4.5 mm., internal diameter 2 to 2.5 mm., supplied by the Westfalisch-Anhaltische Sprengstoff A.G.; and 25 kg. tubular powder containing 23 per cent nitroglycerin, length of tube about 224 and 212 mm., external diameter 7.5 mm., internal diameter 5.5 mm., supplied by the Vereinigten Köln-Rottweiler Pulverfabriken.

2. For the 12-cm. howitzer: 35 kg. nitroglycerin powder (2×2×2), supplied by the W.A.; and 35 kg. powder (4×4×1) containing 4 per cent nitroglycerin, supplied by the K.R. powder company.

The board desired to determine with these samples:

1. The regularity of the muzzle velocity and the force and regularity of the maximum pressure.
2. Visibility by day in rapid fire. (Flame at muzzle and smoke.)
3. Visibility at night.

The results obtained are shown in the table on next page.

From these results the conclusions were as follows:

For the 7-cm. gun, the charge in the case of both samples is considerably larger than the normal, the W. A. about 36 per cent and the K. R. about 20 per cent.

Both samples gave very irregular velocities and pressures. The W. A. powder, however, met fairly well the requirement as to being flameless, as

did the K. R. sample also, but in lesser degree. Both these powders developed somewhat more smoke to observers at a distance of 2500 m. than did the ordinary powder. But, especially during the night firing when observing from the same distance, the great advantage of a diminution of flame, as compared with the ordinary powder, was obvious. This was particularly the case when the guns were masked.

| Piece | Kind of powder* | Weight of charge | Number of shots | M. V. |  | Maximum pressures |  | Temperature of powder deg. C. |
|---|---|---|---|---|---|---|---|---|
| | | | | Average m. sec. | Maximum variation m./sec. | Average atmos. | Maximum variation atmos. | |
| 7-cm. field gun | W. A. | 0.595 | 13 | 496.2 | 22.3 | 1605 | 379 | +3.5 |
| | K. R. | 0.525 | 14 | 504.8 | 21.7 | 1715 | 461 | +7.0 |
| | K. R. | 0.525 | 9 | 507.1 | 18.5 | 1706 | 268 | +5.5 |
| 12-cm. howitzer | W. A. | 0.470 | 14 | 297.0 | 4.2 | 2044 | 161 | +5.0 |
| | W. A. | 0.182 | 14 | 153.5 | 4.8 | —— | —— | +6.0 |
| | K. R. | 0.470 | 14 | 302.8 | 2.4 | 1978 | 214 | +4.5 |
| | K. R. | 0.185 | 15 | 157.1 | 6.3 | —— | —— | +4.5 |

* W. A. refers to the powder of the Westfalisch-Anhaltische Sprengstoff A. G.; K. R. to the powder of the Vereinigte Koln-Rottweiler powder factory. The normal charge for the field gun for 500 m. M. V. is about 0.445 kg.; for the howitzer, 0.485 and 0.195 kg.

For the howitzer, in both samples the charges were slightly smaller than those of the ordinary powder. The results, as far as the regularity of M. V. and pressure are concerned, were good for both samples with the larger charge; but with the smaller charge, while satisfactory with the W. A., were not entirely satisfactory with the K. R. Both samples by day gave practically no flame. During the night firing, observers stationed in the vicinity of the pieces noted a bright flame, although it was less than that accompanying the use of the ordinary powder; but at a distance of 2500 m. the flame was not bright. When the battery was masked, the observers noted either no flame at all or a very dim one, even at night.

In the day firing both samples developed some smoke, which was more or less visible at 2500 m. from the firing point.

The results with the field gun were not such that further experiments with these samples were warranted. The result of the investigation was communicated to the manufacturers and they were asked if they could improve the regularity of M.V. and pressure. They answered in the affirmative, so each factory again delivered 25 kg. of smokeless powder for experimental purposes. Two hundred kilograms of flameless powder were ordered for the howitzers from the K. R. powder works. This was similar to the sample of nitroglycerin powder (4×4×1). The troops were required to carry out experiments with this powder and they reached the same conclusions as the board of test. A storage test was inaugurated in 1910 and will last six years. If after three years the stability proves to be good, a supply of powder that can be used up in three years will be purchased; and, meanwhile, the storage test will be continued. The annual firing test for stability gave the following results in 1911:

| Date | M.V. | | Maximum pressure reduced to a temperature of +10°C. | | Remarks |
|---|---|---|---|---|---|
| | Average m./sec. | Max. variation m./sec. | Average atmos. | Max. variation atmos. | |
| Sept. 26, 1910 | 297.8 | 3.2 | 1916 | 88 | These shots were fired alternately with three shots in which smokeless powder (2×2×2) was used. |
| Sept. 29, 1911 | 296.4 | 3.2 | 1872 | 143 | Six shots had previously been fired with smokeless powder (2×2×2). |

The powder was completely burned. Smoke and lack of flame was the same as in 1910.

Meanwhile the experiments with powder for the field gun were continued. The W.A. powder works supplied tubular nitrocellulose powder. The length of the tubes was 217 and 202 mm., external diameter 4.3, internal 2.1 mm. The K.R. powder works supplied nitroglycerin powder in tubes of which the lengths were 223 and 210 mm., the external diameter 5.9, and the internal 3.7 mm.

The results follows:

| Kind of powder | Weight of charge kg. | Number of shots | M. V. | | Maximum pressures | | Temperature of powder degrees C. |
|---|---|---|---|---|---|---|---|
| | | | Average m./sec. | Max. variation m./sec. | Average atmos. | Max. variation atmos. | |
| W.A. 1911 | 0.590 | 10 | 503.1 | 12.0 | 1765 | 216 | +8.0 |
| 1910 | 0.595 | 13 | 496.2 | 22.3 | 1605 | 379 | +3.5 |
| K.R. 1911 | 0.525 | 10 | 499.1 | 18.2 | 1808 | 356 | +8.0 |
| 1910 | 0.525 | 9 | 507.1 | 18.5 | 1706 | 268 | +5.5 |

On account of erosion of the gun, the charge used was 0.010 kg. more than the normal charge.
The maximum variation in M.V. allowed with standard powder is 9 m. for ten shots.

Both kinds of powder were practically flameless. The observers at 2500 m. often saw no flame during the day firing, although the usual smokeless powder gave a bright flame. During the night firing, observers at the same distance saw a very dull flame, when the gun was not masked; and, when it was masked, no flash was visible.

By both day and night the flame at the muzzle, when the ordinary smokeless powder was used, was very marked. The K.R. powder developed a comparatively large amount of blue smoke; the W.A. powder generally somewhat less, so that by day little was noted at a distance of 2500 m.

Because of these favorable results the board deemed it desirable to investigate to what extent the irregularity in the initial velocity affected the dispersion of shots. To that end, sixteen shots were fired, the range and muzzle velocity being measured. The following results were obtained:

| Kind of powder | Weight of charge kg. | No. of shots | M. V. | | Range | | Mean dispersion | |
|---|---|---|---|---|---|---|---|---|
| | | | Average m./sec. | Max. variation m./sec. | Average m. | Max. variation m. | Longitudinal m. | Lateral m. |
| W.A. | 0.585 | 10 | 502.7 | 18.9 | 2530 | 116 | 52 | 1.8 |
| K.R. | 0.525 | 10 | 497.4 | 11.2 | 2489 | 93 | 26* | 1.9* |

* Of nine shots. An abnormal shot was not considered. If that shot had been included, the longitudinal and lateral dispersion would have been, respectively, 34 m. and 2.6 m. According to the range table, these amount to 23 m. and 1.5 m. at 2500 m.

Contrary to the results of the first trials, the muzzle velocity of the W. A. powder had the greater variation. The W. A. manufactures were of the opinion that the ballistic requirements would be better met in a larger lot of the powder. Meanwhile, 600 kg. of the K.R. powder were ordered, of which 500 kg. were intended for experiments by the troops, and the remainder for further experiments by the board and for stability test. Continued experiments with the powder by the board showed that the M. V. still varied considerably and irregularly. Ten shots fired at 2500 m. gave a maximum variation of 19.6 m., and nineteen shots fired at 500 m. a variation of 12.0 m. The mean longitudinal deviation of the shots at 5000 m. was much more favorable than at 2500 m., just the range where the field artillery should be most effective.

The results were less favorable than in 1911. Great dispersion remains a disadvantage of flameless powder, but the flame at the muzzle has practically disappeared. The stability test will last ten years.

The troops now have the last word to speak in regard to the powder, and this year the field artillery regiments begin their experiments with it. Simultaneous tests of flameless powder and smokeless powder by field artillery will make possible a determination of tactical advantages.

—*Mitteilungen über Gegenstaende des Artillerie-und Geniewesens.*

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## THE FIRST TRIPLE-TURRETED WARSHIPS

The distinction of being the first nation to design and complete a warship carrying three guns in a turret belongs to Italy—the birthplace of so many notable era-making designs and naval innovations—while the kudos of having originated the idea must be awarded to Admiral Cagni, who proposed the triple turret to the Italian Naval Construction Board in 1905. The suggestion was worked out and included in the designs for a 16,000-ton battleship in 1907, but it was not until 1909 that the *Dante Alighieri* was actually commenced at Castellamare, the keel-plate having been laid on June 6th.

The *Viribus Unitis*, the first of Austria's four Dreadnoughts to be completed, was commenced a year later, and although she also carries twelve 12-in. guns in four triple turrets, the disposition of these is very different from that of the Italian ship.

For whereas the *Dante* can only bring three guns to fire fore or aft in the axial line, the *Viribus* brings six guns to bear over similar areas, the grouping of the turrets being after the U. S. *Michigan* style with the second and third

raised to superfire over the first and fourth. Both ships have a twelve gun broadside, but there can be no doubt but that the *Viribus* is the better arrangement of turrets, the training areas of the two inner turrets being more extensive, each turret having a turning arc of 300°.

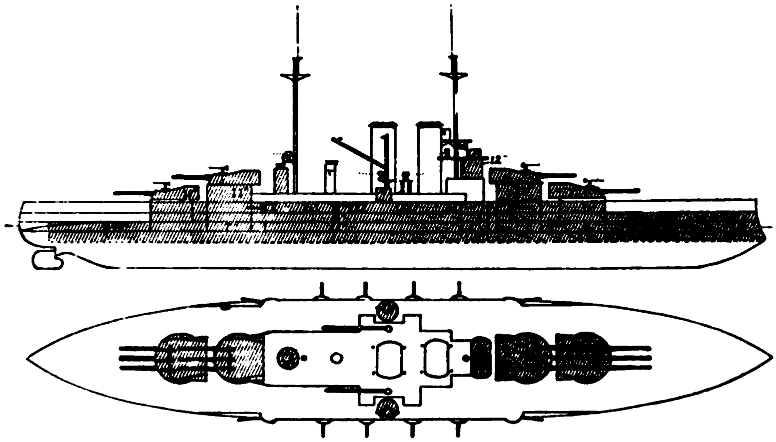
Concerning the advisability of mounting more than two guns per turret much has been written, and even now there seems a diversity of opinion as to the actual results obtained from the triple mounting on trial. Briefly the arguments for and against are as follows:

*Pro.*—(1) Saving of weight, as in mounting twelve guns only four turrets are needed instead of six.

(2) Economical construction, as the ship can be shorter and the engines and boilers more easily arranged when the amidships sections are free from gun mountings.

(3) Facilitated control, as the guns are only in two groups.

(4) Superior concentration of fire, as the three guns might be fired simultaneously.



PLAN OF THE AUSTRIAN BATTLESHIP "VIRIBUS UNITIS" 1385

(5) Augmented fighting power, as it is possible to accommodate more guns on shipboard per the triple than per the double turret.

*Con.*—(1) Liability of three guns being put out of action through a turret jambing, instead of only two.

(2) Lateral movement of the turret increased when a side gun is fired.

(3) Rate of fire diminished, so that three guns cannot fire faster than two.

(4) Blast effects.

The above are the chief desiderata, although of course the lists might be prolonged.

Now as to results: Granting all the pros, the cons only have to be considered.

As regards (1); this can be answered by the simple statement that if six turrets are in action it is more likely that one will be jambed than if only four were exposed to fire, and the likelihood of three guns being placed *hors-de-combat* by one blow is no more than that of a couple of the six double turrets being similarly wrecked.

(2) In actual practice the theories advanced by *Nauticus* and the *Rivista Marittima* were found not to be substantiated, and instead of the turret turning 4° when a lateral fire was fired instead of only 2°, as in the case of twin mountings, the movement was found to be even less than in previous Italian ships. The guns in each turret were also fired simultaneously with a greater elevation than would be given in actual practice, and the heaviest charges and projectiles employed, with completely successful results.

(3) It is claimed that the average rate of fire of each gun can be maintained, but exact figures are lacking.

(4) No bad effects have been experienced in either ship and the following description of the trials of the *Viribus* as given by Rear Admiral Geza Dell' Adami von Tarczal of the Austro-Hungarian Navy throw considerable light upon the vexed question as to whether the occupants of the lower turret really feel any ill results from the super-firing guns.

"After the guns had been tested individually a full salvo of all twelve, loaded with battle charges, was fired on the broadside, without causing any damage to the ship itself or equipment. After this the second and third turrets were trained dead ahead and astern and the three weapons in each loosed off simultaneously. The men in the two lower turrets were somewhat apprehensive as to the effect on themselves of having three guns, with an aggregate energy of something over 142,000 foot-tons, fired a few feet above their heads, but the discharge caused them not the slightest inconvenience nor did it affect the lower turrets in the least." "When these trials were over," he adds, "the crew, elated at the success of the venture spontaneously broke forth into ringing cheers." This description has been here recorded since it would seem to settle the controversy for good and all as to the effects of super-firing.

In passing it might be recalled that a report was circulated at the time of the trials, which claimed exactly the opposite results; the ahead firing was alleged to have thrown the upper turret out of alignment and severely shaken the gun-numbers in the lower turret. These statements were, however, officially contradicted, and since nothing but satisfactory accounts of the *Viribus* have been forthcoming since her commission there is every reason to credit her with being a successful ship.

All of which seems to prove that the triple turret is a practicable proposition. Russia and the U.S.A. have adopted it, and France has gone even further in the effort of concentration and grouped her guns four in a turret, and yet our own Admirality fight shy of the idea, and the Germans are generally believed to have dropped it after experiment. In our case the necessity for its employment has not yet arisen as we have no ships carrying more than ten guns, increase in caliber having always replaced increase in number in the Navy.

Like the *Dante*, the *Viribus* is almost completely armored and carries nothing thicker than 11 in. plates. The main belt is very deep and extends for some distance below the water-line; amidships it is 11 in. thick, thinning to 7 in. under the turrets and 4¾ in. at the extremities. Above this is the 8 in. lower deck side with the 6-in. battery on top, while the 2-1¾ in. protective deck encloses the vitals.

There are two conning towers, that forward being unique in its girth and 12 in. thick (14 in. in the sister ships), and surmounted by an armored range-finder. Aft there is a similar instrument, and also on each side amidships by the boat derricks. There are four submerged torpedo tubes, one

in the bow and stern and each broadside, the model being the new 21-in. torpedo.

Steam is generated in Yarrow boilers (Babcock type in No. VII), as has been the case in practically all the recent Austrian ships, and with Parsons turbines of 25,000 designed H.P. a speed of 21 knots was anticipated, which was exceeded by ⅝ knots on trial. The coal supply is 900-2000 tons, plus oil fuel.

Eleven searchlight projectors are fitted, mounted on the bridges, masts and special platform amidships. The twenty-two boats include two big motor pinnaces, and these are manipulated by central derricks after the usual Austrian pattern.

Both masts are hollow and used as ventilating shafts; the funnels are very wide and are set in with their greatest diameter athwart ships to lessen broadside target. It will be noticed that the ship is without the usual bowsprit—the sign-manual of Austrian war vessels.

The cost of the *Viribus* has been £2,525,000 and it is anticipated that these figures will be exceeded in the sister ships. She and the *Dante* have been compared with contemporary ships carrying 12-in guns, but the *Dante* achieves almost as much on her displacement as the huge *Moreno*. Of the lot the *Kawachi* can only bring eight big guns to bear on each beam and the *Courbet* ten, out of twelve; all the rest have full twelve gun broadsides. So far as figures can speak they show that the *Dante* and *Viribus*, by their triple turrets, have accommodated an armament which other vessels only carry on several thousand tons greater displacement.—*Page's Weekly*.

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## WARSHIP PROGRESS

That the reticence of naval authorites makes records of warship progress not all that they should be one may judge from the remarks of Commander Robinson, who treats of armor and ordnance in Brassey's Naval Annual. Much of what he knows, he says, cannot be published, and foreign admiralties are just as reticent regarding improvements in mountings, projectiles, sights and range finders. A most instructive résumé is given of the progress of gunnery practice in the British navy, which probably represents pretty closely what has been going on in other European countries. As recently as during the Russo-Japanese war range finders were in use which measured ranges to within one-half per cent for 1000 yards; these are no longer regarded as accurate enough, and the latest Barr and Stroud machines measure a range of 10,000 yards within twenty-five yards. The location of the finders has been changed from the masts to other more stable parts of the ship, and in the latest ships they are located inside the turrets with the end projecting at the sides. Transmitters have improved in proportion. Accuracy of range, transmission of the range to the gunner and correcting by "spotting," however, are not all that is required; the relative motion of the two ships engaged is a matter of the utmost importance, as affecting the range, and much work has been done recently in the direction of devising a method by which the targets, speed and course can be ascertained automatically. "Director firing," too, is being rapidly improved in all navies, and in this matter England appears to be leading.

In foreign navies calibers of guns are rising. The 12-inch gun in the

British navy has been succeeded by the 13.5 and now by the 15-inch; practically everywhere the same process is going on, though it is not always easy to say what particular gun is being mounted on any new foreign ship. Equally noticeable is the change in disposition of big guns. The triple turret, of which Italy and the United States were the earliest exponents, is being succeeded in France by a four-gun turret; whether this is a sound move or not is a matter for argument. Similarly the anti-torpedo or secondary batteries are getting heavier, and the 6-inch gun is now the standard gun; it is probably but a question of time before the 6.7, 7.5 and even 9.2-inch weapon return to favor. At least as important as having secondary guns is their location behind armor, and this is being carried out as far as possible in every navy. Anti-aircraft guns, too, are coming in fast, 4.7-inch being the usual caliber.

In gun construction no noticeable change is recorded. The Germans still profess to despise the British wire-wound gun, and to compare British ordnance generally most unfavorably with their own. In France the great question of the year, as of many previous years, has been that of propellants. The conclusion arrived at by the experts appears to have been that the "B" powder was not chemically homogeneous, that it was often very badly made, and that the use of amyl alcohol as a stabilizer was not to be recommended. Now a new stabilizer, diphenylamine, is used, and the so-called "D" powder is said to be perfectly satisfactory, and confidence, wanting recently, has been restored. Italy and Austria have both been concerned with the powder question themselves. In Italy greater care in manufacture is being insisted on; Austria has adopted a substance known as "ammon pulver," composed of from eighty to ninety per cent of ammonium nitrate with wood carbon.

In the development of the torpedo it is noteworthy that the new British ships have more torpedo tubes on the continental system. From the *Bellerophon* to the *King George* the ships have only three tubes, while the German *Nassaus* have six, and the new Japanese battle cruiser *Kongo* has eight. With the increasing range and far greater accuracy of the torpedo it is pretty certain that more tubes will be fitted in future to armored ships. Other changes seem to the Civil and Military Gazette of India to be in prospect; the submersible ship of much larger displacement than any we have at present, the oil-driven I-C-engined battleship, and many other inventions are on their way.—*Army and Navy Journal.*

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## EXTRACTS FROM THE BIMONTHLY ORDNANCE REPORT FOR SEPTEMBER-OCTOBER, 1913

### THE ORDNANCE BOARD

*Mortar primer charges.*—Tests completed. Present design of bag but with core igniter recommended for base charges. Attached to front ends of base charges by straps of powder bag material are increment units making the charges applicable to either zones. These units can be quickly attached or removed permitting a change of zone with same charge without loss of time.

*12-inch mortar, model of 1912.*—Tests completed. Increase of four inches in length of powder chamber was found necessary to obtain desired ballistics. Tests satisfactory. In three rounds fired for uniformity at a

mean range of 19,157 yards the total dispersion in range was 294 yards; and in another group of four rounds at the same range, it was 348 yards, the mean dispersion being about 100 yards.

#### FRANKFORD ARSENAL

*6-inch common shrapnel for the 6-inch Armstrong gun.*—An order has been received for the design and manufacture of sixteen hundred 6-inch common shrapnel weighing 106 pounds each, for use in the 6-inch Armstrong gun. These shrapnel are to be fitted with 30-second combination fuses and will be similar to the shrapnel used for the 6-inch howitzer except that the length will be slightly decreased in order to reduce the weight from 120 to 106 pounds.

*70-second combination fuse.*—A sample lot of 70-second combination fuses are being manufactured for test by the Ordnance Board in connection with the 12-inch mortar shrapnel test.

*Single wire electric primer.*—Service tests were made of these primers during the last target practice and a test of the second lot of one hundred is still in progress at the Sandy Hook Proving Ground. The omission of the shellacked disc, the crimping of the mouth and the new shape of gas check apparently overcome the defects reported to date.

*Aerial bombs.*—An order has been received for the manufacture and shipment of a few aerial bombs to the Signal Aviation School, San Diego, Cal., for experimental firings. The drawings for these have been completed and the work is now in the shops.

#### WATERVLIET ARSENAL

*15-pounder gun.*—Modification of one 3-inch (15-pounder) gun, model of 1902, from its present design to a new design gun of the eccentric block type.

*Armament chests.*—Manufacture of eighty-one combination armament chests for 3-inch (15-pounder) gun, model of 1898, and barbette carriage, model of 1898 MI.

## THE "QUEEN ELIZABETH"

Every new battleship launched at Portsmouth since the original *Dreadnought* took the water there in 1906 has been invested at the time with peculiar interest, because each has been the type-ship of a new class. Thus the *Bellerophon* of 1907 mounted 4-in. instead of 12-pdr. in the anti-torpedo-defense armament. The *St. Vincent* of 1908 was given 12-in. guns of 50 instead of 15 calibers. The *Neptune* of 1909 was the first to fire all her 12-in. guns on either beam by means of the *echelon* principle and the flying bridges. The *Orion* of 1910 brought into use the new 13.5-in. gun and the system of center-line turrets. The *King George V.* of 1911 was notable for an increased torpedo armament of five instead of three tubes. And the *Iron Duke* of 1912 mounted 6-in. instead of 4-in. guns in the anti-torpedo defense battery. So development has been consistent and continuous, but never in any one year has there been such a far-reaching change as has been made in the "Queen Elizabeth" type. The change in armament from ten 13.5-in. to eight 15-in. guns would alone make the new ship notable, although it would not be more striking than the change from the 12-in. to the 13.5-in. gun. It has, however, been accompanied by a large increase of speed. No doubt chiefly on account of

this coal is to be superseded altogether as fuel by oil. The new ship, in a word, starts not merely a new class, but a new species of vessel, for she can hardly be said to belong either to the battleship or battle-cruiser types. In a sense she combines the qualities of past vessels of both types, though, of course, there has necessarily been compromise in some aspects. It was virtually impossible, apparently, to give a vessel armed with eight 15-in. guns the 28 knots of the "Lion" class and of the German *Derfflinger*, but the 25 knots which is decided upon may puzzle the uninitiated. It is too slow to catch a battle-cruiser, and seems too much for use against battleships, against which two more heavy guns might be useful, even at the expense of two or three knots in speed. These, however, are questions which have no doubt been settled after investigation to the satisfaction of the expert advisers of the Board. Presumably the "Queen Elizabeth" type was the last to be designed by Sir Philip Watts before his retirement from the office of Director of Naval Construction.—*The Army and Navy Gazette.*

## Short Notes

*A Correction.*—The professional note, *Triple-Gun Turrets in Italy* which appeared on page 256 of the JOURNAL for September-October, 1913, was, the Italian firm Gio. Ansaldo & C. writes, in error in stating that the battleship, *Dandolo*, is being constructed by the firm of Ansaldo, and in error also in stating that Messrs. Armstrong, Whitworth and Co. are interested in that firm, which, it seems, is exclusively Italian.

*Tetranitranilin.*—Tetranitranilin, an explosive derived from dinitrobenzol, is claimed to be more efficient than picric acid, trinitrotoluol, and other substances now used as the bursters of artillery shells. It is represented by the formula $C_6\ H_2\ (NO_2)_4\ N\ H$, and is obtained by the reduction of dinitrobenzol with a solution of bisulphate of soda. This gives crude metanitranilin, which, on treatment in the usual way with nitric and sulphuric acids, yields yellow crystals of pure tetranitranilin. This substance melts at 130 deg. Cent., decomposes at 215 deg. Cent., and puffs at 220 deg. Cent., so that its safety limits are considerably higher than those of picric acid and T.N.T. It is not hygroscopic, and combustion is more complete than with the two latter substances, as the amount of oxygen contained is larger in proportion to the carbon. Comparative tests in the lead cylinder give a high explosive force, as shown by the following values of distension:—Tetranitranilin, 430; dynamite (75 per cent), 300; picric acid, 297; gun-cotton, 290; trinitrotoluol, 254.

The specific gravity is no less than 1.87, or 15 per cent greater than picric acid, so that a correspondingly greater amount can be packed into a shell. The falling weight test gives a relative degree of sensitiveness of $h=50$, where $h$ is the height of fall, as against 60 for picric acid crystals, so that the new explosive can be used to reduce the sluggishness of T.N.T., for which substance $h=90$. A mixture of 20 per cent T.N.A. (the abbreviation suggested for tetranitranilin) with 80 per cent T.N.T. is said to give excellent results. If, as claimed, T.N.A. can be satisfactorily detonated in a shell without the use of fulminate of mercury, it should prove a valuable explosive for military and naval purposes.—*The Engineer* (London).

*Gun Erosion Investigation.*—The experiments in an effort to solve the mystery and to furnish a prevention of erosion are continuing at the army proving ground at Sandy Hook according to the methods which have been proposed by Mr. J. H. Brown. He has recently made a request that the remaining rounds be fired from the gun, which has been assigned to him for his test according to his method, with a center ignition of the powder charge. Ordinarily the charge is ignited from the rear, but it has been found that that had the effect of driving the unburned powder forward. This was followed by ignition from the front, when it was found by Mr. Brown that the effect was to drive the unburned powder to the rear in such a way as to interfere with the operation of the mechanism of the breechblock. Now the proposition is to have central ignition in an effort to have all the powder burning about the same time. It is probable that this request will be complied with, although the experts are not entertaining much confidence in the practical results. Indeed, very little has been achieved so far by the tests under Mr. Brown looking to the prevention of erosion.—*Army and Navy Register.*

*German Ordnance.*—It would be interesting to hear the reasons which impel Germany to consider the 870-900-pound projectile of her 12-inch gun as destructive at battle range as the 1250-1400 shell fired by the British 13.5-inch B. L. Whatever those reasons are, they must be curiously at variance with the lessons of the Russo-Japanese War. The final and decisive sea action in that war represented a triumph for the big gun. The outstanding feature of Semenoff's account of the battle is his description of the appalling effect of the large H. E. shells which destroyed the Russian battleships, not so much by penetrating armor as by the sheer blasting force of their explosion. It is safe to assume that the bursting charge of a 13.5-inch shell is at least one-third heavier than that of a 12-inch shell. Therefore, the former projectile is certain to do more damage than the latter, other things being equal. Yet this supremely important aspect of the question is ignored by the apologists for the German 12-inch gun.

A 15-inch naval gun has been tested on the Krupp range at Meppen, with most successful results, and the significance of this report is now borne out by the *Marine Rundschau* revelations as to the fact that up to the *Ersatz Worth* no vessel in the German Navy carries a gun over 12 inches in caliber.

The ballistics of the new 15-inch gun, as shown above, show it to be a very powerful weapon, and it has passed a long series of tests. The great weight of this gun and its mountings, together with the massive projectiles and heavy propellent charges used, render it impracticable to mount more than eight of the type in a ship of reasonable dimensions. Precisely the same considerations, it will be recalled, are understood to have governed the selection of the armament for the British *Warspites* now building. Unless all the published details of these last-named ships are inaccurate, Britain and Germany are now constructing battleships of very similar design, but it is impossible to say whether Germany is aiming at the high speed which is to be the feature of the *Warspites.* As regards battle-cruisers, it is noteworthy that Germany prefers sharply to differentiate them from battleships by giving them much lighter guns. Probably the intention is to sacrifice hitting power to speed and coal endurance.—*United States Naval Institute Proceedings.*

*German Battleships.*—The *König* class are a departure from the *Kaiser* class in that all five turrets are placed on the center line and in the fact of

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# BOOK REVIEWS

**The Truth About Chickamauga.** By Archibald Gracie. Cambridge, Mass: Houghton Mifflin Company. 6½"x9½." xxxi + 461 pp. 49 il. 9 maps. 1911.

*La Grande Encyclopédie* says, "In its largest sense, History can be defined as the actual representation, or systematic exposition of all kinds of past events in the form of narrative." Colonel Gracie's book certainly fulfills these requirements. In the early chapters one is apt to wonder why the generally accepted tales of those who should know whereof they speak should be subjected to an iconoclastic assault; but, as the reader progresses, he is struck by the scholarly presentation of fact after fact supported by evidence of unquestionable authority.

We, in America, are rather prone to accept historically what we want to believe rather than what is true—witness the difference between the ordinary school history of the United States and Upton's *Military Policy of the United States.* Upton's version is undoubtedly correct, but the school version is more acceptable to our national vanity.

Colonel Gracie handles his subject like an able lawyer. Without fear or favor he presents his indictment, for such it is, and proves by time and by established record where troops and their commanders were at critical times of that titantic struggle, and shows how they could not have been elsewhere. It is inconceivable that the glaring errors in present acceptation, as pointed out in this volume, should be disregarded by those whose duty it is to preserve for future generations the historical or true presentation of that great battle. The most striking points made by the author are: (1) General Rosecran's failure, prior to the engagement, to grasp the true situation; (2) his fixing, after the engagement, upon a lesser object to claim as accomplished, when failure had overtaken his real object; (3) Granger's having testified to matters concerning which he could not possibly have had personal knowledge; and (4) establishment of the true history of the part taken by the 9th Indiana, 21st Ohio, 22nd Michigan, and 89th Ohio regiments.

No one who wishes to know the truth about Chickamauga should fail to read Colonel Gracie's volume.

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**Notes sur le Canon de 75 et son Reglement, a l'usage des Officiers de toutes armes.** 4th Edition. By Capitaine H. Morliere. Paris: Libraire Militaire Berger-Levrault, 5-7 Rue des Beaux-Arts. 5½" x 9". 136 pp. 65 il. Paper. 1913. Price 2 fr.

This is an admirable instruction book on the French field gun, which limits itself to a treatment of the principles of the essential training devices of the piece and to the drill and fire control of the piece and battery in position. It might well be termed "Elementary Gunnery for the Field Artillery." The dry bones of the regulations are herein clothed with explanations and

considerations such as are really essential to intelligent service of the field gun by its personnel, preceded by a brief discussion of fundamental ballistic principles, and supplemented by short appendices giving, generally in tabular form, some of the most valuable data in regard to the piece, its properties, and its trajectory. The subjects considered include Description of essential mechanisms; Pointing and laying; The mechanism of fuse setting and effect; Instruments employed in laying for range and direction. Service of the piece and orders of fire. Choice of position. Opening and controlling of fire and changes of objective or alteration of extent of [illegible] front fire by the battery.

The pamphlet is attractive as much for what it omits as for what it contains. The matters discussed are presented in lucid arrangements of the minimum of words, and the ever-present temptation to diverge into consideration of nonessentials which, however interesting, is successfully resisted. An excellent statement of the principle of the rigidity of the trajectory is worthy of quotation. Note that the French term this the *principle of the rotation of the trajectory*. "The trajectory of a projectile is a rigid line fixed with *reference* to the gun, which turns with it about the trunnions." A profusion of excellent diagrams illuminate the text.

The pamphlet should have great interest for field artillerymen because of the information and suggestions which it contains. It contains little of value to the coast artillery as such, but if this latter arm of the service is to be trained as a reserve for the mobile artillery, then no better model for the necessary brief instruction pamphlet for use in their peace training or at the outbreak of war can be imagined.

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**Abraham Lincoln. The People's Leader in the Struggle for National Existence. By George Haven Putnam, Litt. D., late Brevet-Major, 176th Regt. N. Y. Vols. New York: G. P. Putnam's Sons, 2 West 45th St. 6″ x 8½″. 292 pp. $1.25 Net.**

This volume had its beginning in an address delivered by Mr Putnam on the occasion of the celebration in New York City of the hundredth anniversary of the birth of Abraham Lincoln, and, before reaching its present form, passed through the stage of a monograph prepared for the author's children and grandchildren. Its origin and growth tend to make it most readable and entertaining.

Anecdotes abound. One that concerns the mortar boats used by General Grant against Fort Donelson is of especial interest to artillerymen and is quoted here.

"Sometime in the nineties I was sojourning with the late Abram S. Hewitt at his home in Ringwood, New Jersey. I noticed, in looking out from the piazza, a mortar, properly mounted on a mortar-bed * * *. I asked my host what was the history of this piece of ordnance. * * * 'The mortar was given to me by President Lincoln, as also was the mortar-bed * * * I made this mortar-bed,' said Hewitt, 'together with some others, and Lincoln was good enough to say that I had in this work rendered a service to the state. It was in December, 1861, when the expedition against Fort Donelson and Fort Henry was being organized at Fort Cairo under the leadership of General Grant. Grant reported that the field-pieces at his command would not be effective against the earthworks that were to be shelled and made requisition for mortars,' * * * * The Ordnance

Department reported to the Secretary of War and the Secretary to Lincoln that mortars were on hand but that no mortar-beds were available. * * * The further report was given to Lincoln that two or three months' time would be required to manufacture the thirty mortar-beds that were needed. A delay of any such period would have blocked the entire purpose of Grant's expedition. In his perplexity, Lincoln remembered that in his famous visit to New York two years before, he had been introduced to Mr. Hewitt, 'a well-known iron merchant,' as 'a man who does things.' Lincoln telegraphed to Hewitt asking if Hewitt could make thirty mortar-beds and how long it would take Hewitt told me that the message reached him on a Saturday evening at the house of a friend. * * * At noon on Monday, Hewitt wired to Lincoln that he could make thirty mortar-beds in thirty days. In another hour he received by wire instructions from Lincoln to go ahead. In twenty-eight days he had the thirty mortar-beds in readiness * * * *. The train [carrying the mortars] was addressed to 'U. S. Grant, Cairo,' and each car contained a notification, painted in white on a black ground, 'not to be switched on the penalty of death.' That train got through * * *. Six schooners, each equipped with a mortar, were hurried up the river to support the attack of the army on Fort Donelson. * * * 'Towards the end of the War,' he [Mr. Hewitt] continued, 'when there was no further requirement for mortars, I wrote to Mr. Lincoln and asked whether I might buy a mortar with its bed. Lincoln replied promptly that he had directed the Ordnance Department to send me mortar and bed with "the compliments of the administration." I am puzzled to think,' said Hewitt, 'how that particular item in the accounts of the Ordnance Department was ever adjusted, but I am very glad to have this reminiscence of the war and of the President.' "

The volume includes the address delivered by Mr. Lincoln at Cooper Institute, New York, on February 27, 1860—"the address which made him President"—together with an interesting introduction by Justice Charles C. Nott, historical and analytical notes by Justice Nott and Mr. Cephas Brainerd, and the correspondence between Mr. Lincoln and a representative of the Young Men's Republican Union, before which the address was delivered.

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**A Prisoner of War in Virginia, 1864-5. By George Haven Putnam, Litt. D., late Brevet-Major, 176th Regt. N. Y. Vols. New York: G. P. Putnam's Sons, 2 West 45th Street. 6" x 8½". 127 pp. 5 il. $1.00 Net, $1.10 postpaid.**

Like his *Abraham Lincoln*, Mr. Putnam's account of his experiences as a prisoner of war in Virginia found its way to the public in consequence of having been first presented as an address. It is reprinted, with additions, from the report of an address made to the New York Commandery of the U. S. Loyal Legion on December 7, 1910; and in the second edition includes an appendix setting forth statistics of Northern prisoners from the report of 1st Lieutenant Thomas Sturgis, 57th Massachusetts Volunteers.

Being an account of personal experiences under the very trying circumstance of prisoner of war in the hands of an army, itself underfed and underclothed, it is not to be expected that the volume should lack numerous

instances of statements of facts observed from a point of view to which the reader cannot follow. On page 66, for instance, we are told, "Our guards [in Danville] represented rather a curious mixture of good-natured indifference and a kind of half-witted cruelty." And, in another place, referring to the Confederate authorities, we find: "Even if there had been an honest desire on their part to save the lives or to protect the health of the helpless men for whom they were responsible, the task would have been difficult; but it was quite evident that there was no such desire."

There are many examples of heroism in the book; interesting accounts of the devices of the prisoners for their own entertainment; and, of course, numerous scenes of pathos.

But the account is not confined to the point of view of a prisoner. Throughout the volume are interesting and instructive comments on the general history of the war, and a portion of it is devoted to the author's experiences after being paroled.

It is an interesting volume.

# KEY

## TO

# INDEX TO CURRENT MILITARY LITERATURE

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The periodicals cited are arranged by government, and each periodical is assigned a symbol consisting of an initial, or other abbreviation of the governmental designation, and a numeral indicative of the periodical's position in an alphabetical arrangement of the Journal of the United States Artillery's exchanges under that government.

Prices of subscription are given in the currencies of the countries of publication.

All the periodicals cited are preserved in the Library of the Coast Artillery School at Fort Monroe, Virginia.

### ARGENTINE

| | | |
|---|---|---|
| *Ar–0.5* | *Anuario del Instituto Geografico Militar de la Republica Argentina*<br>3ª Division del Estado Mayor del Ejército<br>Buenos Aires | Annual |
| *Ar–1* | *Boletin del Centro Naval*<br>Florida 659, Buenos Aires | Bimonthly<br>Per year $^{m}/_{n}$11.90 |
| *Ar–1.5* | *Revista del Circulo Militar*<br>255 Maipu<br>Buenos Aires | Monthly<br>Per year $12.00 |
| *Ar–2* | *Revista Militar*<br>Ministerio de Guerra, Santa Fe 1461<br>Buenos Aires | Monthly<br>Per year $^{m}/_{n}$9.00 |

### AUSTRIA

| | | |
|---|---|---|
| *Au–1* | *Mitteilungen aus dem Gebiete des Seewesens*<br>Pola | Monthly<br>Per year 17 M |
| *Au–2* | *Mitteilungen ueber Gegenstaende des Artillerie-und Genie-Wesens*<br>Getreidemarkt 9<br>Wien, VI. | Monthly<br>Per year 20 M |
| *Au–3* | *Streffleurs Militaerische Zeitschrift zugleich Organ der militaerwissenschaftlichen Vereine*<br>I. Graben, 13. Wien | Monthly<br>Per year 28 M |
| *Au–4* | *Zeitschrift des Oesterreichischen Ingenieur und Architekten Vereines*<br>I. Eschenbachgasse, No. 9<br>Wien | Weekly<br>Per year 34 K |

### BELGIUM

| | | |
|---|---|---|
| *Be–1* | *Belgique Militaire, La*<br>Rue Albert de Latour 50<br>Schaerbeck, Brussels | Weekly<br>Per year 12 fr 50 |

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| *Be–2* | *Revue de l'Armée Belge*<br>24 Rue des Guillemins, Liege | Bimonthly<br>Per year 13 fr |
| *Be–3* | *Revue de l'Ingénieur et Index Technique*<br>70, Boulevard d'Anderlecht, Brussels | Quarterly<br>Per year 30 fr |

## BRAZIL

| | | |
|---|---|---|
| *Br–1* | *Boletim Mensal do Estado Maior do Exercito*<br>Ministerio de Guerra<br>Rio de Janeiro | Monthly |
| *Br–2* | *O Tiro*<br>Rio de Janeiro | Monthly |
| *Br–3* | *Revista Maritima Brazileira*<br>Rua D. Manoel n. 15<br>Rio de Janeiro | Monthly<br>Per year 12$000 |

## CHILE

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|---|---|---|
| *C–1* | *Memorial del Estado Mayor del Ejercito de Chile*<br>Talleres del Estado Mayor-General<br>Santiago | Monthly |
| *C–2* | *Revista de Marina*<br>Casilla del Correo 976, Valparaiso | Monthly<br>Per year $15.00 |

## COLOMBIA

| | | |
|---|---|---|
| *Co–1* | *Memorial del Estado Mayor del Ejercito de Colombia*<br>Jefe del Departamento de Historia del<br>Estado Mayor-General<br>Bogota | Bimonthly<br>Per year $0 50 oro |

## DENMARK

| | | |
|---|---|---|
| *D–1* | *Militært Tidsskrift*<br>Copenhagen | Semimonthly<br>Per year 8 kr |

## FRANCE

| | | |
|---|---|---|
| *F–1* | *Archives Militaires*<br>Librairie Militaire Berger-Levrault<br>5-7 Rue des Beaux-Arts, Paris | Quarterly<br>Per year 14 fr |
| *F–2* | *France Militaire, La*<br>10 Rue Danton, Paris | Daily<br>Per year 32 fr |
| *F–3* | *Génie Civil, Le*<br>6 Rue de la Chausée d'Antin, Paris | Weekly<br>Per year 45 fr |
| *F–4* | *Journal des Sciences Militaires*<br>30 Rue et Passage Dauphine (VI^e^)<br>Paris | Semimonthly<br>Per year 40 fr |
| *F–5* | *Liste Navale Francaise*<br>Quai Cronstadt, au coin de la Rue Neuve<br>Toulon | Quarterly<br>Per year 9 fr |
| *F–6* | *Memoires et Travaux de la Société des Ingénieurs Civils*<br>19 Rue Blanche<br>Paris | Monthly<br>Per year 36 fr |
| *F–7* | *Memorial des Poudres et Salpetres*<br>55 Quai des Grands-Augustins, Paris | Semiannually<br>Per year 13 fr |

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| *F–8* | *Mois Scientifique et Industriel, Le*<br>8, Rue Nouvelle, Paris | Monthly<br>Per year 25 fr |
| *F–9* | *Monde Militaire, Le*<br>6 Rue de la Chaise, Paris | Fortnightly<br>Per year 6 fr |
| *F–10* | *Revue d'Artillerie*<br>5 Rue des Beaux-Arts, Paris | Monthly<br>Per year 22 fr |
| *F–11* | *Revue de Cavalerie*<br>5 Rue des Beaux-Arts, Paris | Monthly, ex. Aug.<br>Per year 27 fr |
| *F–12* | *Revue du Génie Militaire*<br>5 Rue des Beaux-Arts, Paris | Monthly<br>Per year 27 fr |
| *F–13* | *Revue d'Infanterie, La*<br>10 Rue Danton, Paris | Monthly<br>Per year 25 fr |
| *F–13.5* | *Revue de l'Aviation de l'Automobile et des Sports, La*<br>3, Avenue de l'Opéra,<br>Paris | <br>Monthly<br>Per year 18 fr |
| *F–14* | *Revue Maritime*<br>30 Rue et Passage Dauphine, Paris | Monthly<br>Per year 36 fr |
| *F–15* | *Revue Militaire des Armées Etrangères*<br>Librairie Chapelot<br>30 Rue et Passage Dauphine, Paris | Monthly<br>Per year 15 fr |
| *F–16* | *Yacht, Le, Journal de la Marine*<br>55 Rue Chateaudun, Paris | Weekly<br>Per year 32 fr |

## GERMANY

| | | |
|---|---|---|
| *G–1* | *Artilleristische Monatshefte*<br>Bernburgerstr, 24-25 Berlin, S. W. II | Monthly<br>Per year 27 M |
| *G–2* | *Eisen-Zeitung*<br>Verlag von Otto Elsner, Berlin, S. 42 | Weekly<br>Per year 12 M |
| *G–3* | *Ingenieur, Der*<br>Cordel & Renné<br>Fritschestr. 47, Charlottenburg 4 | Semimonthly<br>Per year 16 M |
| *G–3.5* | *Kriegstechnische Zeitschrift*<br>E. S. Mittler & Sohn<br>Königliche Hofbuchhandlung,<br>Kochstrasse, 68-71, Berlin, S. W. | 10 Nos. per yr.<br>Per pear 10 M. |
| *G–4* | *Marine Rundschau*<br>Koch Strasse, 68-71, Berlin, S.W. | Monthly<br>Per year 10 M |
| *G–5* | *Militaer Wochenblatt*<br>*With monthly Supplement*<br>Koch Strasse, 68, Berlin, S.W., 12 | 3 times a week<br>Per year 18 M |
| *G–6* | *Schiffbau*<br>Zimmerstr. 9, Berlin, S.W., 68 | Semimonthly<br>Per year 20 M |
| *G–8* | *Ueberall*<br>Verlag: Boll und Pickardt<br>Berlin, N.W. 7 | Monthly<br>Per year 15.6 M |
| *G–9* | *Zeitschrift fuer das Gesamte Schiess-und Sprengstoffwesen*<br>J. F. Lehmann's Verlag, Paul Heysestrasse 26,<br>Munich | <br><br>Semimonthly<br>Per year 26 M |

## HOLLAND

| | | |
|---|---|---|
| H–1 | *Orgaan der Vereeniging ter beoefening van de Krijgswetenschap*<br>Z. O. Buitensingel 224<br>The Hague | Monthly<br>Per year 4 florins |
| H–2 | *Wetenschappelijk Jaarbericht. Vereeniging ter beoefening van der Krijgswetnschap*<br>Z. O. Buitensingel 224<br>The Hague | Yearly<br>Per year 2 florins |

## ITALY

| | | |
|---|---|---|
| I–1 | *Lista Navale Italiana*<br>Officina Poligrafica Italiana, Rome | Quarterly<br>Per year 15 L |
| I–2 | *Rendiconti delle Esperienze e Degli Studi Eseguiti Nello Stabilimento di Esperienze e Costruzioni Aeronautiche del Genio*<br>Viale Giulio Cesare N. 2, Rome | Occasional<br>Per year 13.50 L |
| I–3 | *Rivista di Artiglieria e Genio*<br>Tipografia Enrico Voghera<br>Via Astalli 15, Rome | Monthly, ex. July<br>Per year 20 L |
| I–4 | *Rivista Marittima*<br>Officina Poligrafica Italiana<br>Rome | Monthly<br>Per year 25 L |

## MEXICO

| | | |
|---|---|---|
| M–1 | *Boletin de Ingenieros*<br>War Dept., Mexico City | Monthly |
| M–2 | *Revista del Ejercito y Marina*<br>Departamento de Estado Mayor<br>City of Mexico | Monthly |

## NORWAY

| | | |
|---|---|---|
| N–1 | *Norsk Artilleri-Tidsskrift*<br>Christiania | Bimonthly<br>Per year 6 kr |
| N–2 | *Norsk Militært Tidsskrift*<br>Christiania | Monthly<br>Per year 8 kr |

## PERU

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|---|---|---|
| Pe–1 | *Boletin del Ministerio de Guerra y Marina*<br>Apartado de Correo No. 91, Lima | Fortnightly |

## PORTUGAL

| | | |
|---|---|---|
| Po–1 | *Anais do Club Militar Naval*<br>43 Rua do Carmo, Lisbon | Monthly<br>Per year 4$200 |
| Po–2 | *Revista de Artilharia*<br>Rua do Carmo, 43, 2°., Direito, Lisbon | Monthly<br>Per year 3$000 rs |
| Po–3 | *Revista de Engenheria Militar*<br>27 Rua Nova do Almada, Lisbon | Monthly<br>Per year 3$600 rs |
| Po–4 | *Revista Militar*<br>Largo da Annunciada, 9, Lisbon | Monthly<br>Per year 3$000 rs |

## RUSSIA

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|---|---|---|
| R–1 | *Imperial Nicholai War Academy Recorder, The*<br>St. Petersburg | Monthly<br>Per year 6 rubles |
| R–2 | *News of the Officers' Artillery School*<br>Zarskoe Selo | Monthly<br>Per year 10 rubles |

## SPAIN

| | | |
|---|---|---|
| Sp–1 | *Informacion Militar del Extranjero*<br>Madrid | Monthly |
| Sp–2 | *Memorial de Artilleria*<br>Museo de Artilleria, Madrid | Monthly<br>Per year 18 ps |
| Sp–3 | *Revista Cientifico-Militar*<br>Paseo de San Juan, 201, Barcelona | Semimonthly<br>Per year 40 ps |
| Sp–4 | *Revista General de Marina*<br>Ministerio de Marina, Madrid | Monthly<br>Per year 25 ps |

## SWEDEN

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|---|---|---|
| Sn–1 | *Artilleri-Tidsskrift*<br>Artillerigarden, Stockholm | Bimonthly<br>Per year 6 kr |

## SWITZERLAND

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|---|---|---|
| Sd–1 | *Allgemeine Schweizerische Militaer-Zeitung*<br>Basel | Weekly<br>Per year 10 fr |
| Sd–2 | *Revue Militaire Suisse*<br>Avenue Juste Olivier, Lausanne | Monthly<br>Per year 15 fr |
| Sd–3 | *Schweizerische Monatschrift fuer Offiziere Aller Waffen*<br>Frauenfeld | Monthly<br>Per year 5 fr |
| Sd–4 | *Schweizerische Zeitschrift fuer Artillerie und Genie*<br>Frauenfeld | Monthly<br>Per year 8 fr |

## UNITED KINGDOM OF GREAT BRITAIN AND IRELAND ITS COLONIES AND POSSESSIONS

| | | |
|---|---|---|
| UK–1 | *Arms and Explosives*<br>Effingham House<br>Arundel Street, Strand, London, W.C. | Monthly<br>Per year 7s |
| UK–2 | *Army and Navy Gazette*<br>22 Essex Street, Strand<br>London, W.C. | Weekly<br>Per year £1 12s 6d |
| UK–3 | *Army Review, The*<br>Wyman & Sons, Ltd.<br>Fetter Lane, London, E. C. | Quarterly<br>Per copy 1s |
| UK–4 | *Canadian Military Gazette*<br>Room 16, Trust Bldg.<br>Ottawa, Canada | Semimonthly<br>Per year $2.50 |
| UK–5 | *Commonwealth Military Journal, The*<br>Melbourne, Australia | Quarterly |
| UK–6 | *Electrician, The*<br>1, 2 and 3, Salisbury Court, Fleet Street<br>London | Weekly<br>Per year 30s |

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|---|---|---|
| *UK–7* | *Electrical Review*<br>4, Ludgate Hill, London, E. C. | Weekly<br>Per year £1 10s |
| *UK–8* | *Engineer, The*<br>33 Norfolk Street, Strand<br>London, W.C. | Weekly<br>Per year £1 16s |
| *UK–9* | *Engineering*<br>35-36 Bedford Street, Strand<br>London, W.C. | Weekly<br>Per year £1 16s |
| *UK–10* | *Iron & Coal Trades Review, The*<br>165 Strand, London, W. C. | Weekly<br>Per year 27s |
| *UK–11* | *Journal of the Royal Artillery, The*<br>Woolwich | Monthly<br>Single copy 2s 6d |
| *UK–12* | *Journal and Proceedings, Royal Society N. S. W.*<br>5 Elizabeth St., North Sydney, N. S. W. | |
| *UK–13* | *Journal of the Royal United Service Institution*<br>Whitehall, London, S.W. | Monthly<br>Per year 24s |
| *UK–14* | *Journal of the United Service Institution of India*<br>Simla, India | Quarterly<br>Per year Rs 8 |
| *UK–15* | *Junior Institution of Engineers, The*<br>39 Victoria St., Westminster, S.W.<br>London | Single copy 1s |
| *UK–17* | *Page's Weekly*<br>22 Henrietta Street, Covent Garden<br>London, W. C. | Weekly<br>Per year £1 5s |
| *UK–18* | *Photographic Journal*<br>35 Russell Square, London | Occasional<br>Copies 1s each |
| *UK–19* | *Proceedings of the Institution of Civil Engineers*<br>Great George St., Westminster, London, S. W. | |
| *UK–20* | *Proceedings of the Institution of Mechanical Engineers*<br>Story's Gate St., James Park, London, S. W. | |
| *UK–21* | *Royal Engineers Journal, The*<br>Chatham | Monthly<br>Per year 15s |
| *UK–23* | *Transactions of the Canadian Society of Civil Engineers*<br>176 Mansfield Street<br>Montreal, Canada | |
| *UK–24* | *Transactions of the Institution of Naval Architects*<br>5 Adelphi Terrace, London, W. C. | |
| *UK–25* | *United Service Gazette*<br>43, 44 Temple Chambers<br>London, E. C. | Weekly<br>Per year £1 10s 6d |
| *UK–26* | *United Service Magazine*<br>31, Haymarket<br>London, S. W. | Monthly<br>Per year £1 1s |

## UNITED STATES

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|---|---|---|
| *US–1* | *Aeronautics*<br>122 East 25th Street, New York City | Monthly<br>Per year $3.00 |

| | | |
|---|---|---|
| *US-2L* | *American Historical Review* | Quarterly |
| | The Macmillan Company | Per year $4.00 |
| | 41 N. Queen Street, Lancaster, Pa., or | |
| | 66 Fifth Avenue, New York City | |
| *US-3L* | *American Journal of International Law, The* | Quarterly |
| | Baker, Voorhis & Co., 45 John St., N.Y. | Per year $5.00 |
| *US-4* | *American Journal of Mathematics* | Quarterly |
| | Johns Hopkins Press | Per year $5.00 |
| | Baltimore, Md. | |
| *US-5* | *Arms and The Man* | Weekly |
| | 1502 H Street, N.W., Washington, D. C. | Per year $3.00 |
| *US-6* | *Army and Navy Journal* | Weekly |
| | 20 Vesey Street, New York | Per year $6.00 |
| *US-7* | *Army and Navy Register* | Weekly |
| | Washington, D. C. | Per year $3.00 |
| *US-8* | *Bulletin of the American Geographical Society* | Monthly |
| | Broadway at 156th Street, New York City | Per year $5.00 |
| *US-9* | *Bulletin of the American Institute of Mining Engineers* | Monthly |
| | 29 West 39th Street, New York | Per year $10.00 |
| *US-10* | *Bulletin of the American Mathematical Society* | Ten Nos. per yr. |
| | 501 West 116th Street, New York. | Per year $5.00 |
| *US-11* | *Bulletins and Circulars of the Bureau of Standards* | |
| | Department of Commerce and Labor | |
| | Washington, D. C. | |
| *US-12L* | *Bulletin of the Pan American Union* | Monthly |
| | Seventeenth and B Streets, N.W. | Per year $2.00 |
| | Washington, D. C. | |
| *US-13* | *Bulletin Iowa State College* | Monthy |
| | Ames, Iowa | |
| *US-14* | *Bulletin of the University of Illinois* | |
| | Urbana, Illinois | |
| *US-15* | *Bulletins, Circulars and Technical Papers* | Occasional |
| | *Bureau of Mines* | Free |
| | Department of the Interior | |
| | Washington, D. C. | |
| *US-16L* | *Canal Record* | Weekly |
| | Ancon, Canal Zone, Isthmus of Panama | Per copy 5c |
| *US-17.5* | *Colliery Engineer, The* | Monthly |
| | Scranton, Pa. | Per year $2.00 |
| *US-18* | *Compressed Air Magazine* | Monthly |
| | Compressed Air Magazine Co. | Per year $1.50 |
| | Easton, Pa. | |
| *US-19* | *Confederate Veteran* | Monthly |
| | Nashville, Tenn. | Per year $1.00 |
| *US-20* | *Craftsman, The* | Monthly |
| | 41 W. 34th Street, New York | Per year $3.00 |
| *US-21* | *Electric Journal, The* | Monthly |
| | 200 Ninth Street, Pittsburgh, Pa. | Per year $1.50 |
| *US-21.5* | *Electrical Engineering* | Monthly |
| | Dalton, Georgia | Per year $1.00 |

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| US–22 | *Electrical Review and Western Electrician*<br>Heisen Building<br>608 South Dearborn Street, Chicago | Weekly<br>Per year $3.00 |
| US–24 | *Engineering Magazine, The*<br>140-142 Nassau Street, New York | Monthly<br>Per year $3.00 |
| US–25 | *Engineering News*<br>505 Pearl Street, New York | Weekly<br>Per year $5.00 |
| US–27 | *Field Artillery Journal, The*<br>U. S. Field Artillery Association<br>1701 Pennsylvania Avenue, N.W.<br>Washington, D.C. | Quarterly<br>Per year $4.00 |
| US–28 | *Flying and The Aero Club of America Bulletin*<br>297 Madison Ave., New York | Monthly<br>Per year $3.00 |
| US–29 | *General Electric Review*<br>General Electric Company<br>Schenectady, New York | Monthly<br>Per year $2.00 |
| US–30 | *Infantry Journal*<br>U. S. Infantry Association<br>814 Seventeenth Street, N.W<br>Washington, D. C. | Bimonthly<br>Per year $3.00 |
| US–31L | *Journal of American History, The*<br>3 West 43rd Street, New York | Quarterly<br>Per year $3.00 |
| US–31.5 | *Journal of Efficiency Society, Inc.*<br>29 West 39th Street, New York City | Monthly<br>Per year $3.00 |
| US–32 | *Journal of Industrial and Engineering Chemistry, The*<br>The American Chemical Society,<br>Easton, Pa. | Monthly<br>Per year $6.00 |
| US–33 | *Journal of The American Society of Mechanical Engineers, The*<br>29 West 39th Street,<br>New York City | Monthly<br>Per year $3.00 |
| US–34 | *Journal of the American Society of Naval Engineers*<br>Navy Department, Washington, D.C. | Quarterly<br>Per year $5.00 |
| US–35 | *Journal of the Association of Engineering Societies*<br>31 Milk Street<br>Boston, Mass. | Monthly<br>Per year $3.00 |
| US–36 | *Journal of the Franklin Institute*<br>15 South Seventh Street, Philadelphia, Pa. | Monthly<br>Per year $5.00 |
| US–37 | *Journal of the Military Service Institution*<br>Governor's Island, New York | Bimonthly<br>Per year $3.00 |
| US–38 | *Journal of the U. S. Artillery*<br>Fort Monroe, Virginia | Bimonthly<br>Per year $2.50 |
| US–39 | *Journal of the U. S. Cavalry Association*<br>Fort Leavenworth, Kansas | Bimonthly<br>Per year $2.50 |
| US–40 | *Journal of the Western Society of Engineers*<br>1735 Monadnock Block<br>Chicago, Illinois | Monthly<br>ex. July and Aug.<br>Per year $3.00 |
| US–41 | *Machinery*<br>49-55 Lafayette Street, New York | Monthly<br>Per year $2.50 |
| US–42 | *Metal Industry, The*<br>99 John Street, New York | Monthly<br>Per year $1.00 |

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| *US–43* | *Military Surgeon, The*<br>535 North Dearborn Street<br>Chicago, Illinois | Monthly<br>Per year $3.50 |
| *US–45L* | *National Geographic Magazine, The*<br>Hubbard Memorial Hall<br>Washington, D. C. | Monthly<br>Per year $2.50 |
| *US–46* | *National Guard Magazine, The*<br>136-140 East Gay Street<br>Columbus, Ohio | Monthly<br>Per year $1.00 |
| *US–47* | *Navy, The*<br>Southern Building<br>Washington, D. C. | Monthly<br>Per year $2.00 |
| *US–47.5L* | *North American Review, The*<br>The North American Review Publishing Company<br>New York City | Monthly<br>Per year $4.00 |
| *US–48* | *Official Gazette of the United States Patent Office, The*<br>Supt. of Documents, Gov. Printing Office<br>Washington, D. C. | Weekly<br>Per year $5.00 |
| *US–49* | *Pennsylvania Magazine of History and Biography*<br>Philadelphia, Pa. | Quarterly<br>Per year $3.00 |
| *US–50* | *Physical Review*<br>41 North Queen Street, Lancaster, Pa. | Monthly<br>Per year $6.00 |
| *US–51* | *Polytechnic, The*<br>Troy, N. Y. | 10 Nos. per yr.<br>Per year $2.00 |
| *US–52* | *Popular Mechanics*<br>318 West Washington Street, Chicago, Ill. | Monthly<br>Per year $1.50 |
| *US–53* | *Practical Electricity and Engineering*<br>608 South Dearborn Street, Chicago, Ill. | Monthly<br>Per year $1.00 |
| *US–54L* | *Proceedings of the American Institute of Electrical Engineers*<br>33 West 39th Street<br>New York | Monthly<br>Per year $10.00 |
| *US–55* | *Proceedings of the American Philosophical Society*<br>104 South Fifth Street, Philadelphia, Pa. | |
| *US–56* | *Proceedings of the American Society of Civil Engineers*<br>220 West 57th Street<br>New York | 10 Nos. per year<br>Per year $8.00 |
| *US–57* | *Proceedings of The Engineers' Club of Philadelphia*<br>1317 Spruce Street<br>Philadelphia, Pa. | Quarterly<br>Per Vol. $2.00 |
| *US–58* | *Proceedings of The Engineers' Society of Western Pennsylvania*<br>2511 Oliver Building<br>Pittsburgh, Pa. | 10 Nos. per year<br>Per year $5.00 |
| *US–59* | *Proceedings of the U. S. Naval Institute*<br>Annapolis, Md. | Quarterly<br>Per year $3.00 |
| *0* | *Professional Memoirs*<br>Washington Barracks, D. C. | Bimonthly<br>Per year $3.00 |
| *ↄ1* | *Reactions*<br>Goldschmidt Thermit Company<br>90 West Street, New York | Quarterly<br>Per year $0.25 |

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|---|---|---|
| *US-63* | *Science* | Weekly |
| | 41 North Queen Street, Lancaster, Pa. | Per year, $5.00 |
| *US-64* | *Science Conspectus* | Five issues per yr |
| | Massachusetts Institute of Technology | |
| | Boston, Mass. | |
| *US-65* | *Scientific American* | Weekly |
| | 361 Broadway, New York | Per year $3.00 |
| *US-66L* | *Scientific American Supplement* | Weekly |
| | 361 Broadway, New York | Per year $5.00 |
| *US-68* | *Seventh Regiment Gazette, The* | Monthly |
| | 30 West 33rd Street, New York | Per year $1.50 |
| *US-71* | *Stevens Indicator* | |
| | Stevens Institute of Technology | Quarterly |
| | Hoboken, N. J. | Per year $1.50 |
| *US-72* | *Technical World Magazine* | Monthly |
| | 5758 Drexel Avenue, Chicago, Ill. | Per year $1.50 |
| *US-73* | *Telephone Engineer* | Monthly |
| | Monadnock Building, Chicago, Ill. | Per year $2.00 |
| *US-74* | *Transactions of the American Society of Civil Engineers* | |
| | 220 West 57th Street, New York | Yearly |
| | | Per year $12.00 |
| *US-75* | *Transactions of the Society of Naval Architects and Marine Engineers* | |
| | 29 West 39th Street, New York | |
| *US-76L* | *Virginia Magazine of History and Biography, The* | |
| | Virginia Historical Society | Quarterly |
| | Richmond, Va. | Per year $5.00 |

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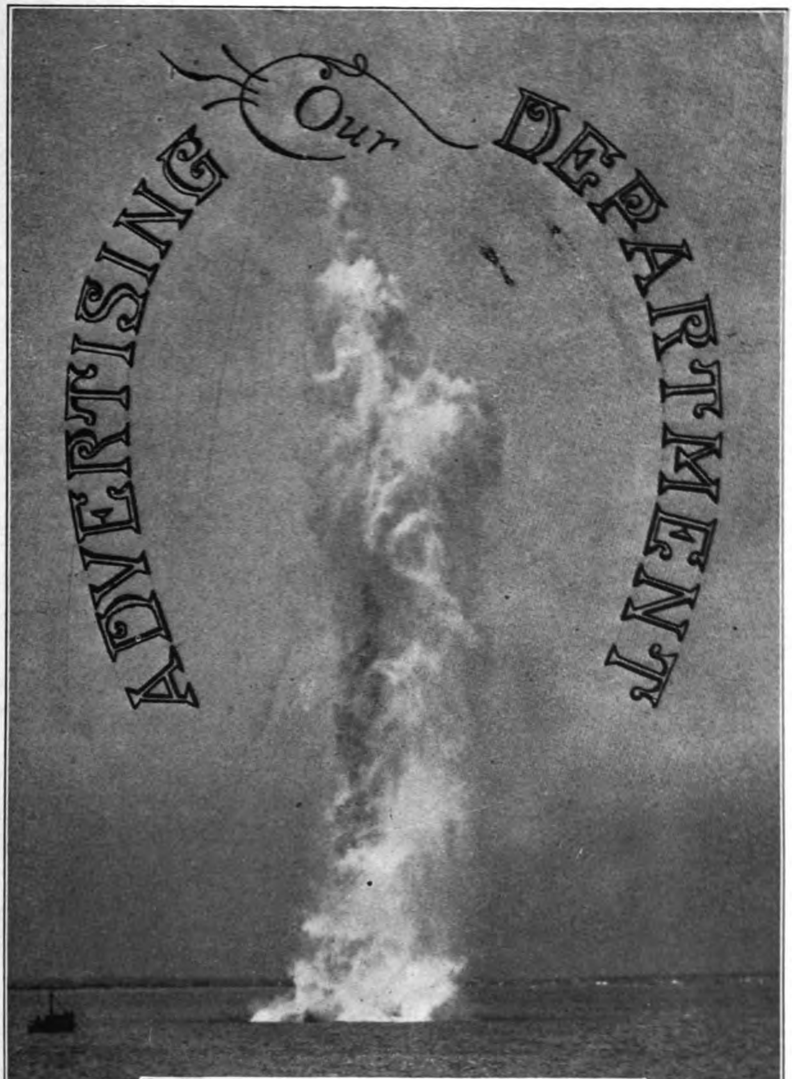


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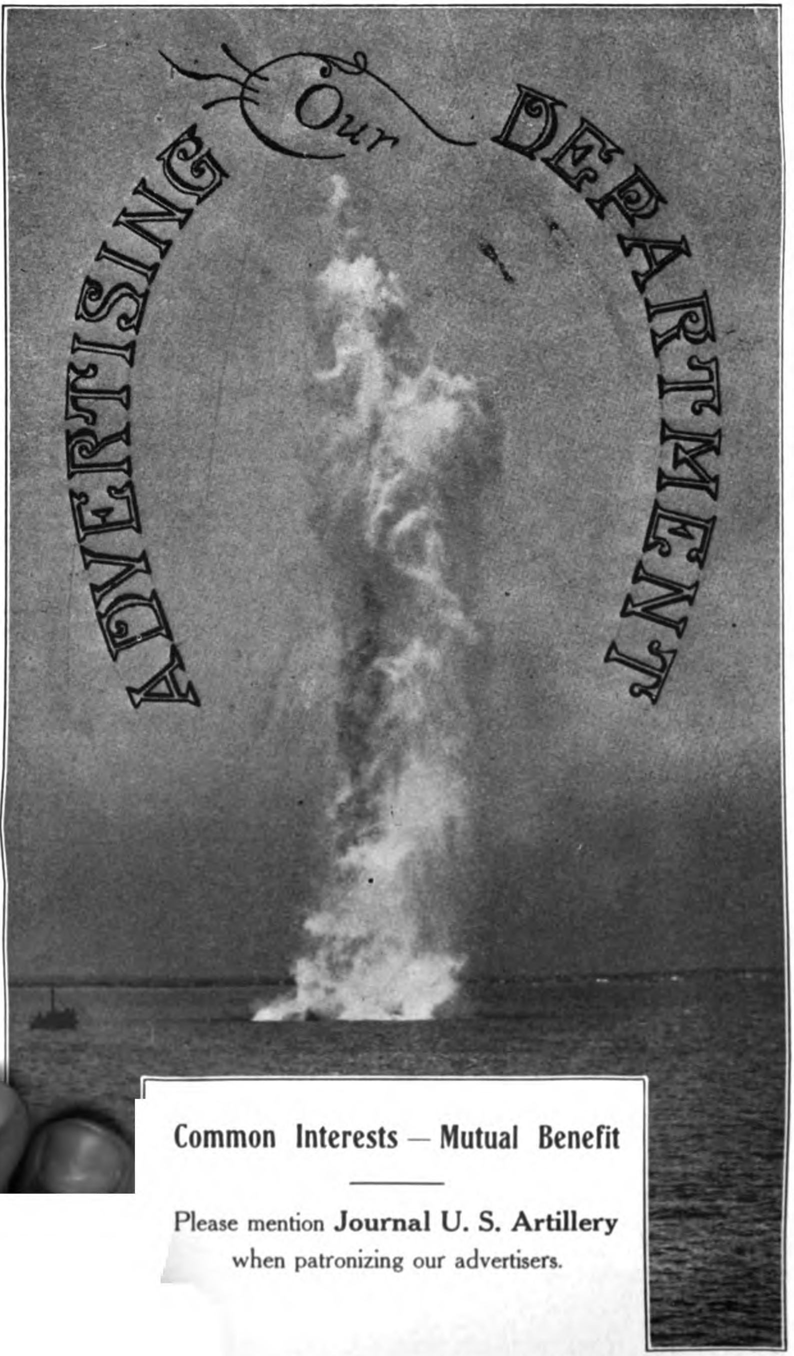


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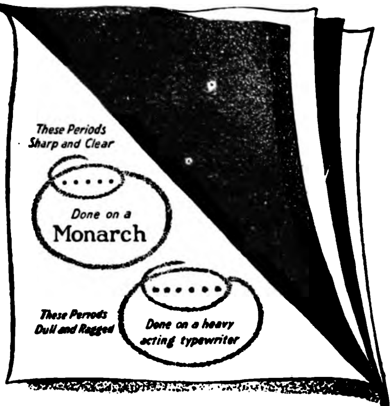


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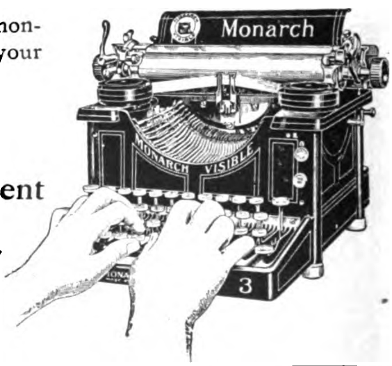



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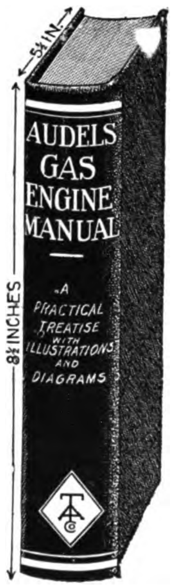


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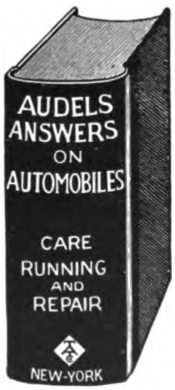


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